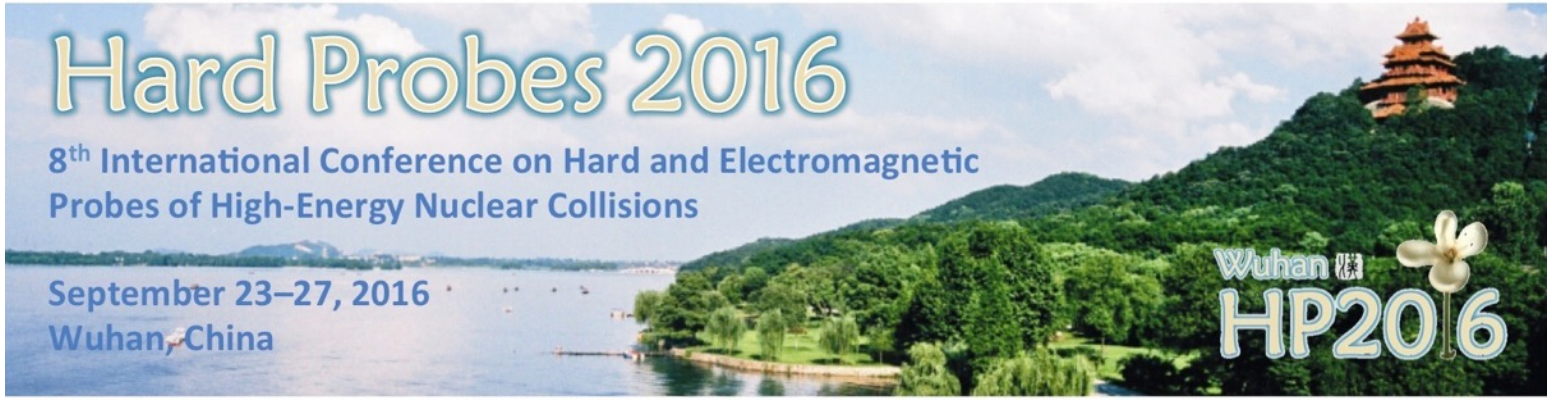
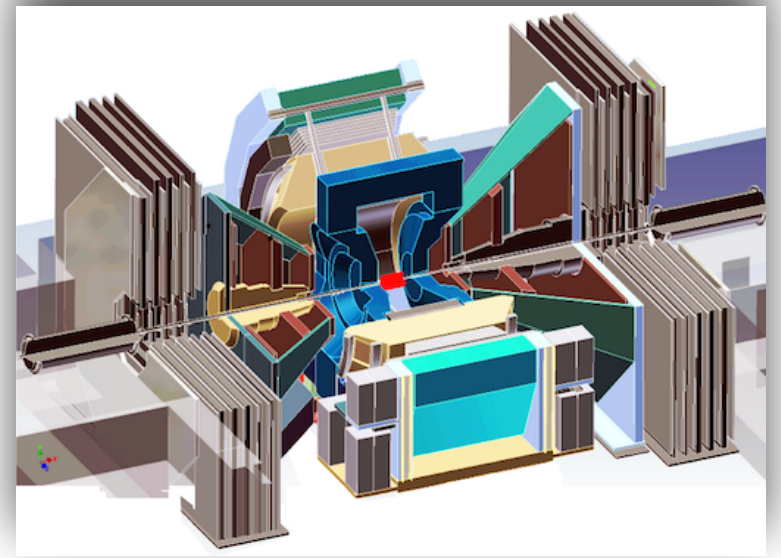
Report from PHENIX

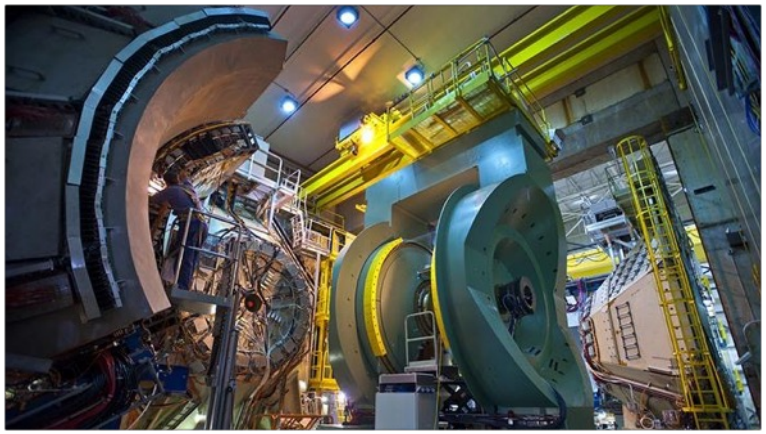
Xiaochun He
Georgia State University
For the PHENIX Collaboration



Outline

- PHENIX status
- New PHENIX Results
  - Jet and π^0
  - Heavy flavor
  - Direct Photon & Flow





PHENIX Data Taking Mission Completed

Email from the PHENIX spokesperson (Dr. Yasuyuki Akiba) on 6/27/2016

"This morning at 7:42, we ended RUN459344. The beam was dumped at ~7:50. This is the end of RUN16 and the end of PHENIX data taking. We had the first collision of Au+Au at 56 GeV on June 15, 2000."

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PHENIX data production and analyses continue !

The Last Chance to See the PHENIX Apparatus

Picture taken on July 31, 2016 during the RHIC/PHENIX Summer Sunday

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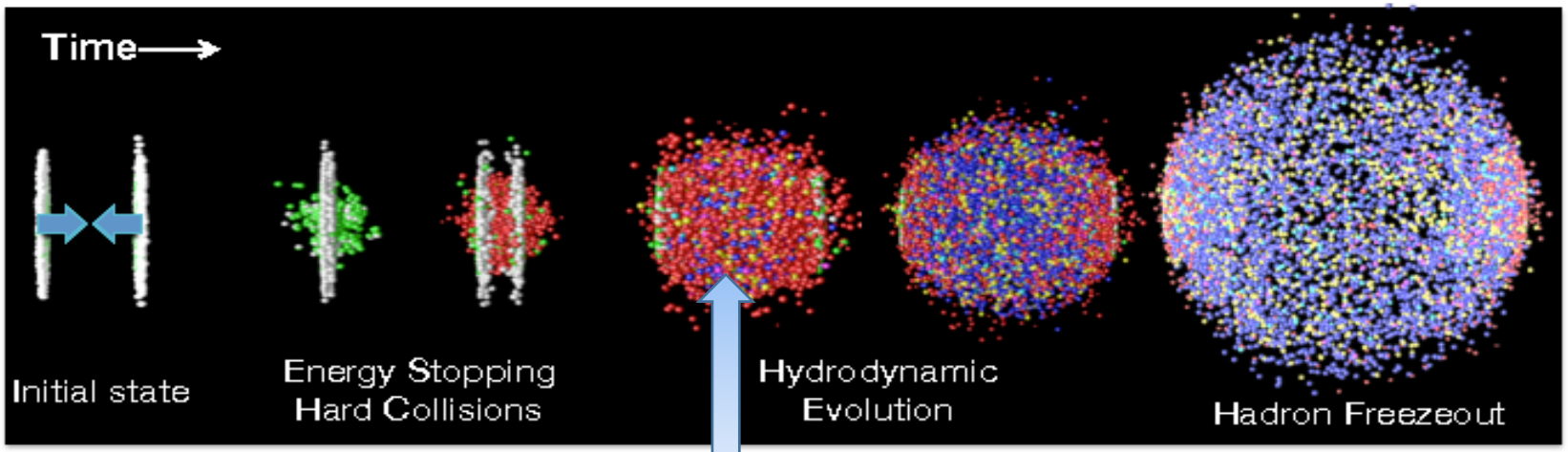
Picture taken on July 31, 2016 during the RHIC/PHENIX Summer Sunday

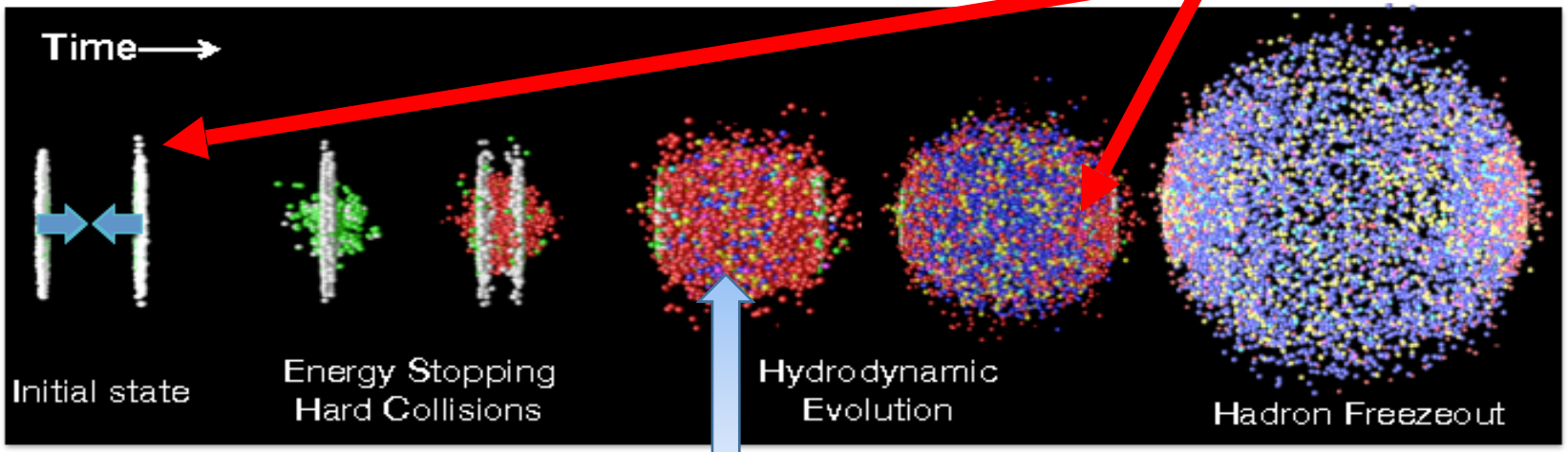
- PHENIX detectors is expected to be completely removed from the current IR region within one year period.
- This opens the new opportunity for precision QGP characterization – **sPHENIX**. See Anne Sickles' talk on Tuesday Sep 27 ("Future Experiments").

Known Results



- Medium is **HOT/DENSE** - Based on the measurement of low-momentum direct-photon production and particle production suppression in Au+Au.
  [PHENIX: PRC 91. 064904 (2015), etc.]
- Medium **FLOWS** - Based on the measurement of the anisotropic flow coefficients v2, v3, and v4 in Au+Au
  [PHENIX: PRC 93. 051902(R) (2015)]

Known Results and Uncertainties



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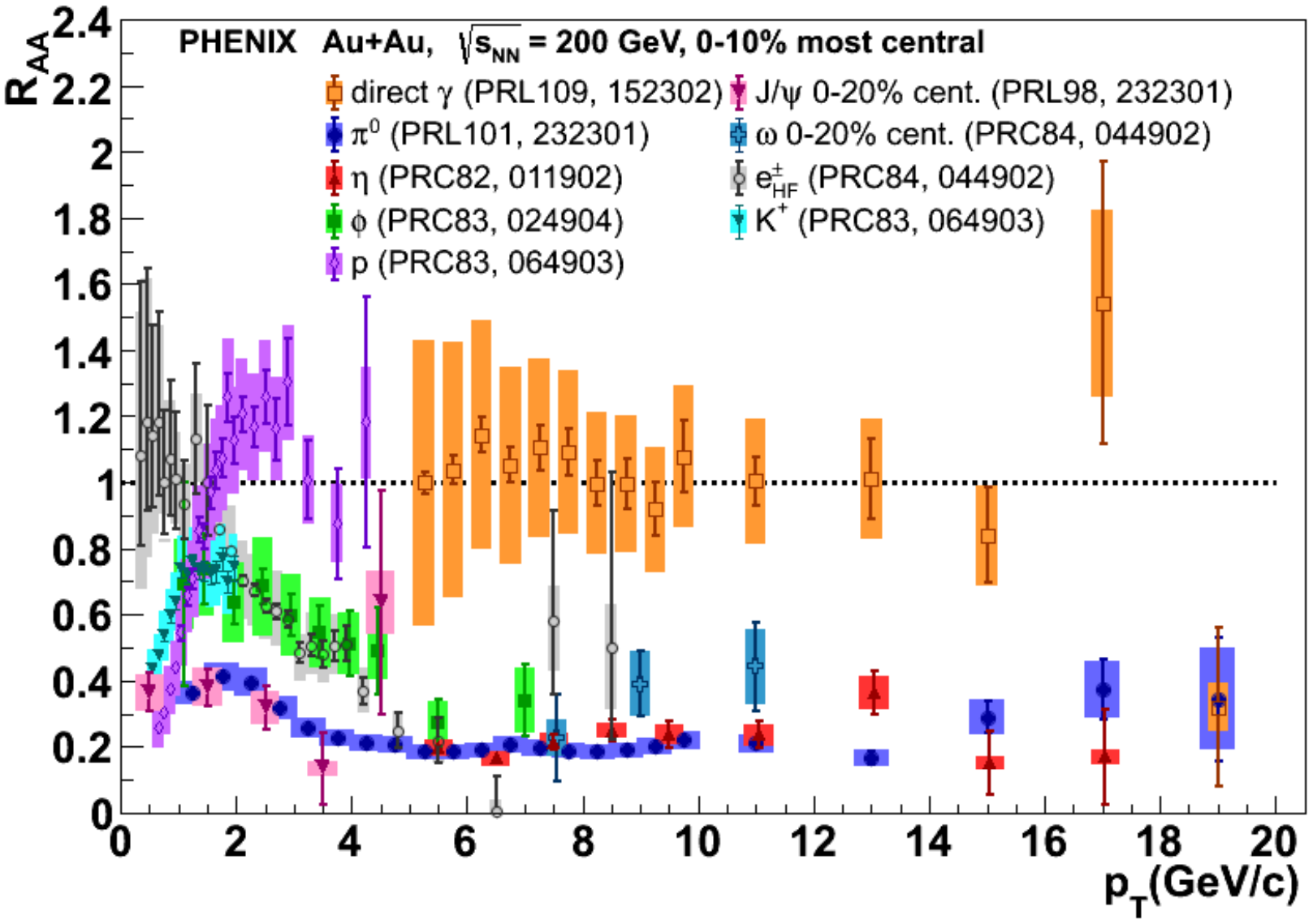
Compilation of R_{AA} in Au+Au



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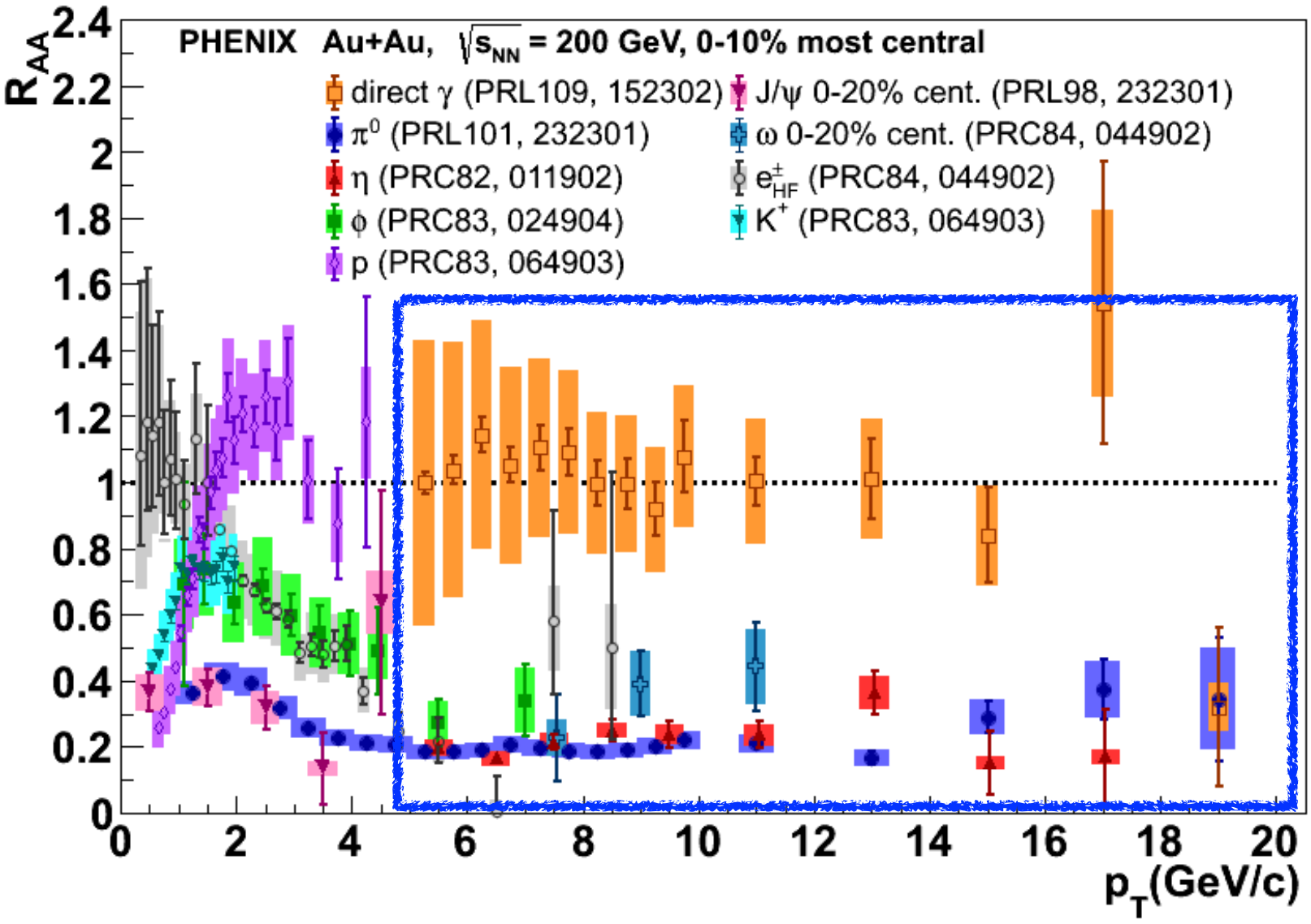

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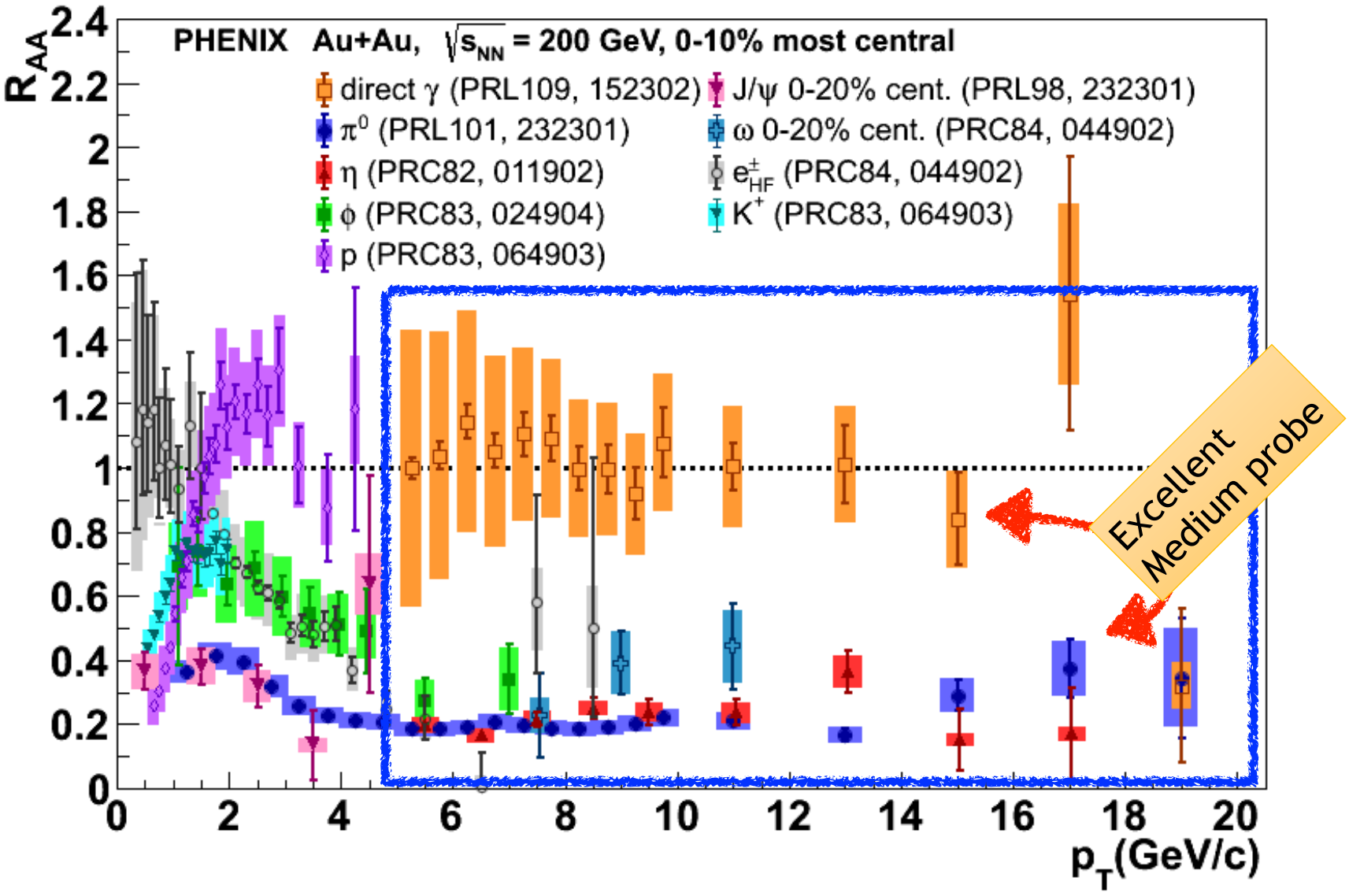
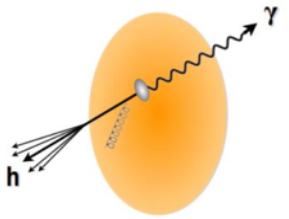


Jet and π^0 Measurements

Direct Photon-Hadron Correlations

- Given the color-transparency of photons, the study of photon-jet correlation reveal the details of QGP induced jet energy loss in heavy ion collisions



$$p_T^{\gamma} \approx p_T^{jet} \qquad z_T = \frac{p_T^h}{p_T^{\gamma}} \qquad \Longrightarrow \qquad D_q(z_T) = \frac{1}{N_{evt}} \frac{dN(z_T)}{dz_T}$$

$$I_{AA} = \frac{Y_{AA}}{Y_{pp}} \sim \frac{D_{AA}(z_T)}{D_{pp}(z_T)}$$

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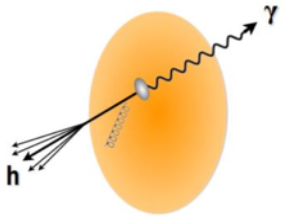

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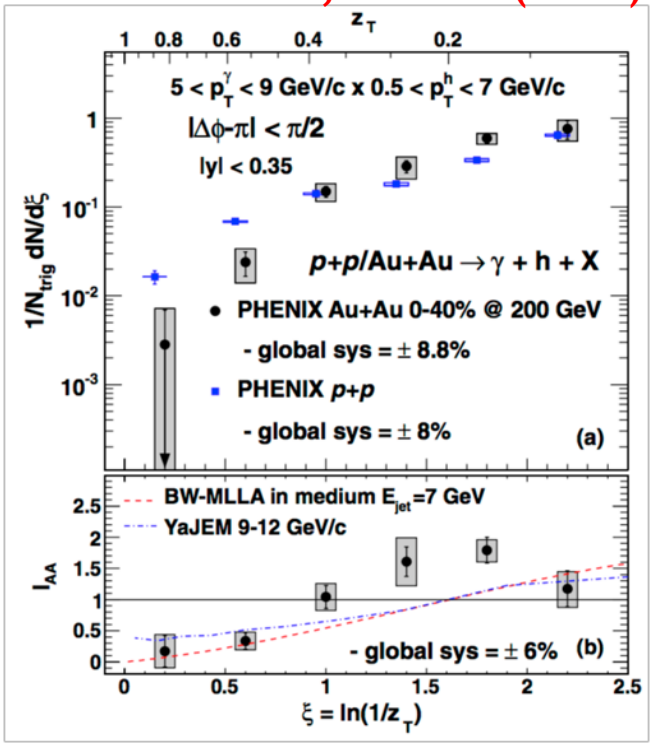
PHENIX - PRL 111, 032301 (2013)



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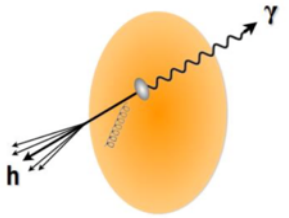

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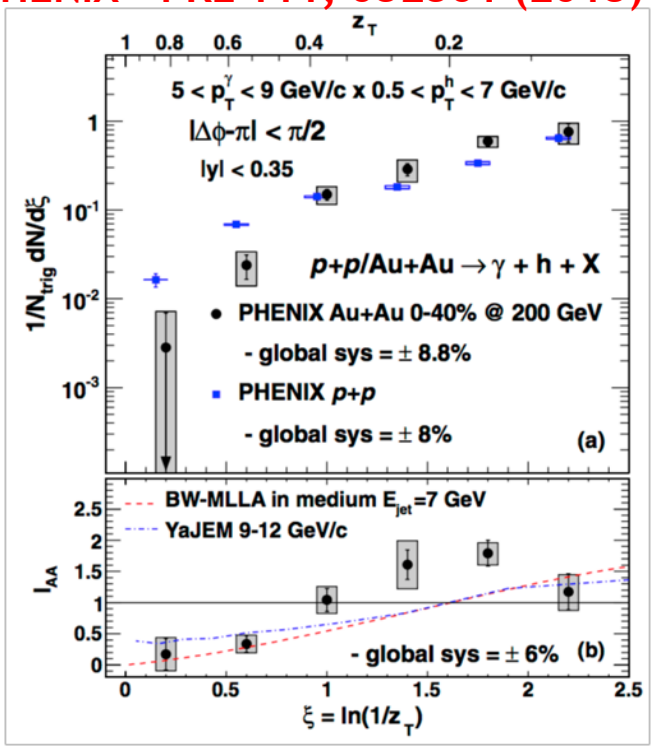
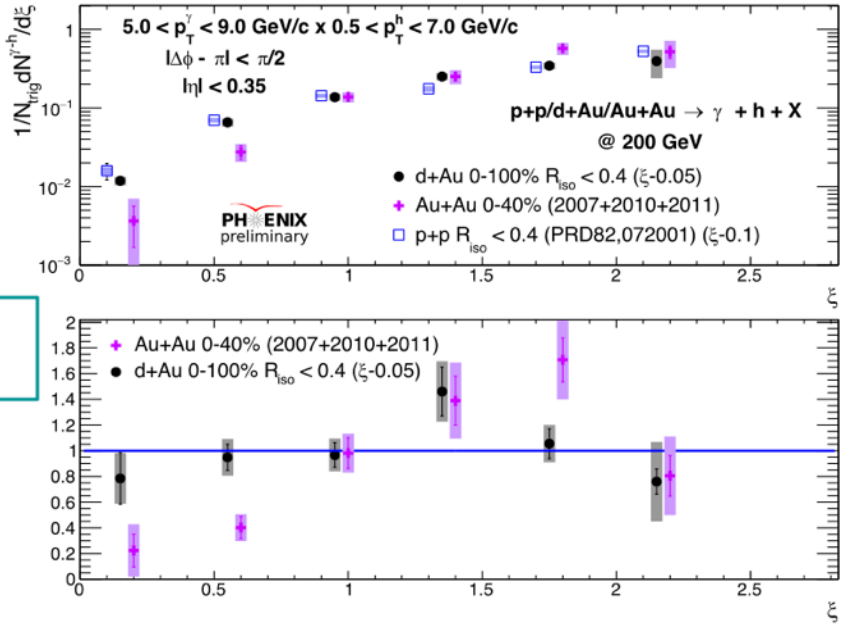


New

$$I_{dA} = \frac{Y_{dA}}{Y_{pp}}$$



See Huijun Ge's talk

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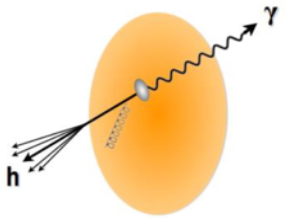

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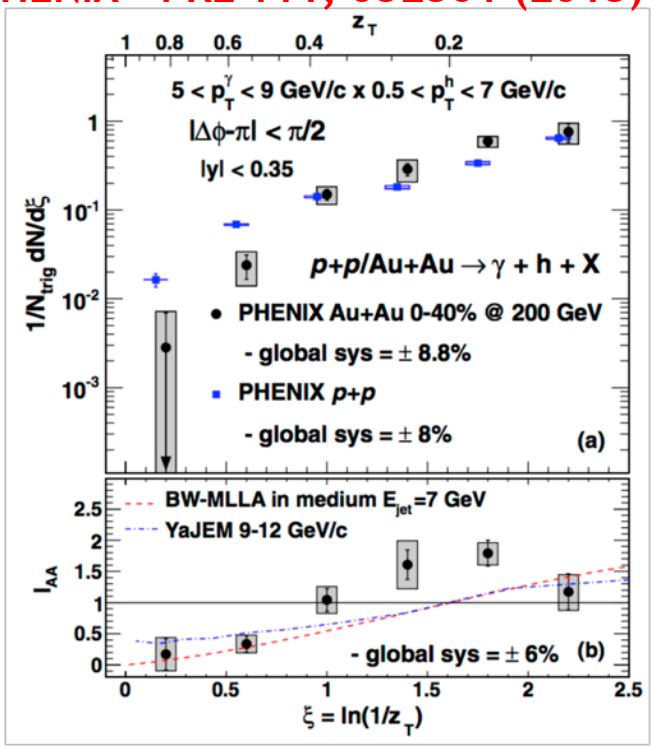

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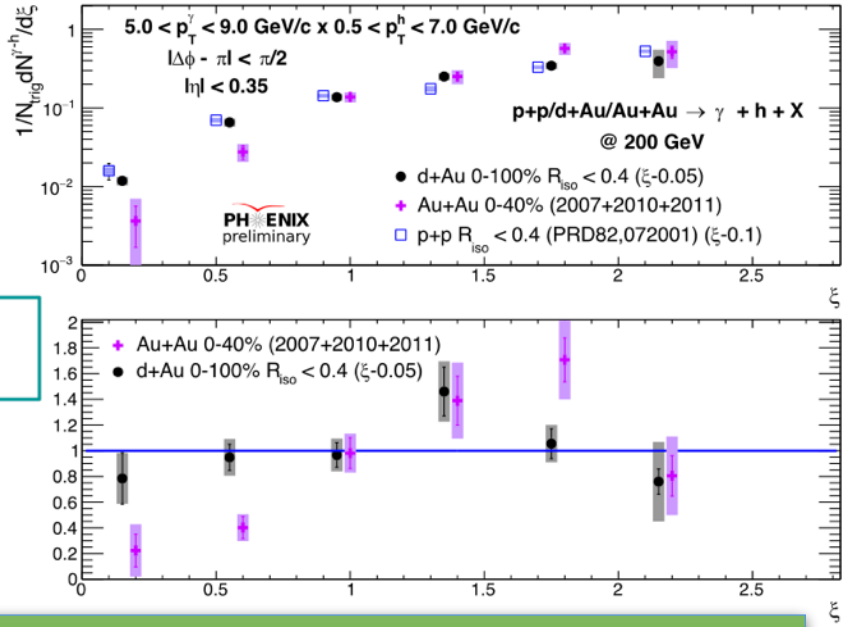

$$I_{dA} = \frac{Y_{dA}}{Y_{pp}}$$

In d+Au, no significant modification to the yield is observed.

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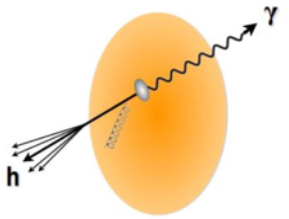

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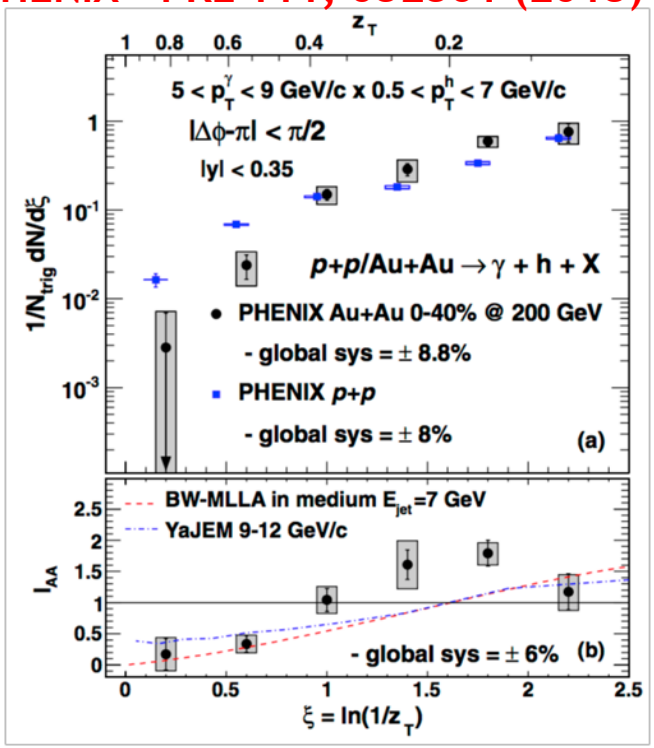

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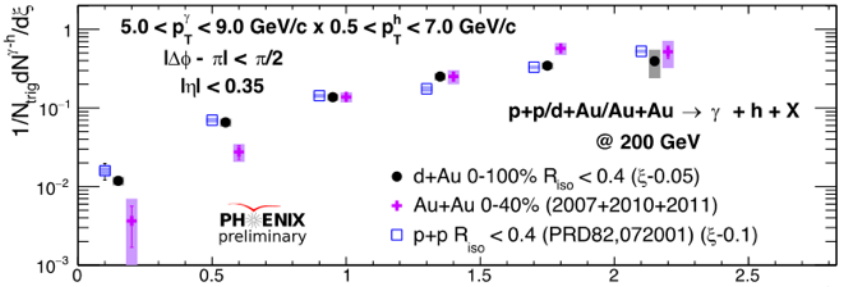

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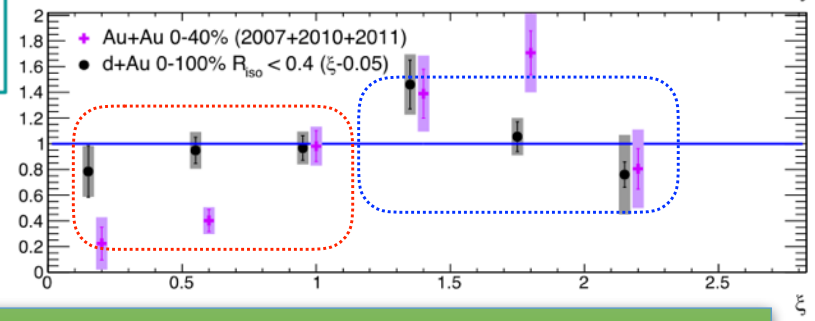
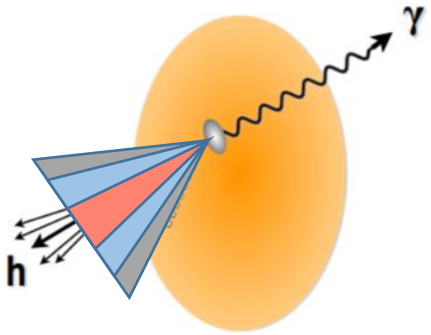
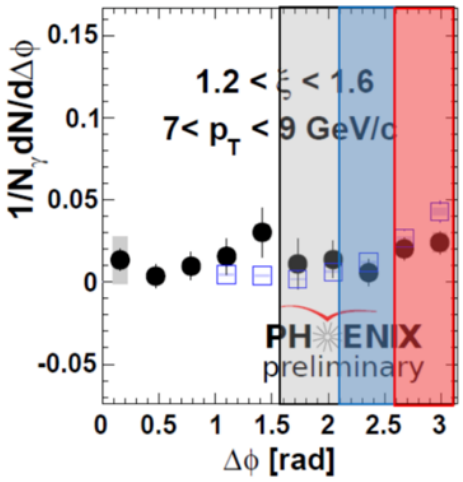


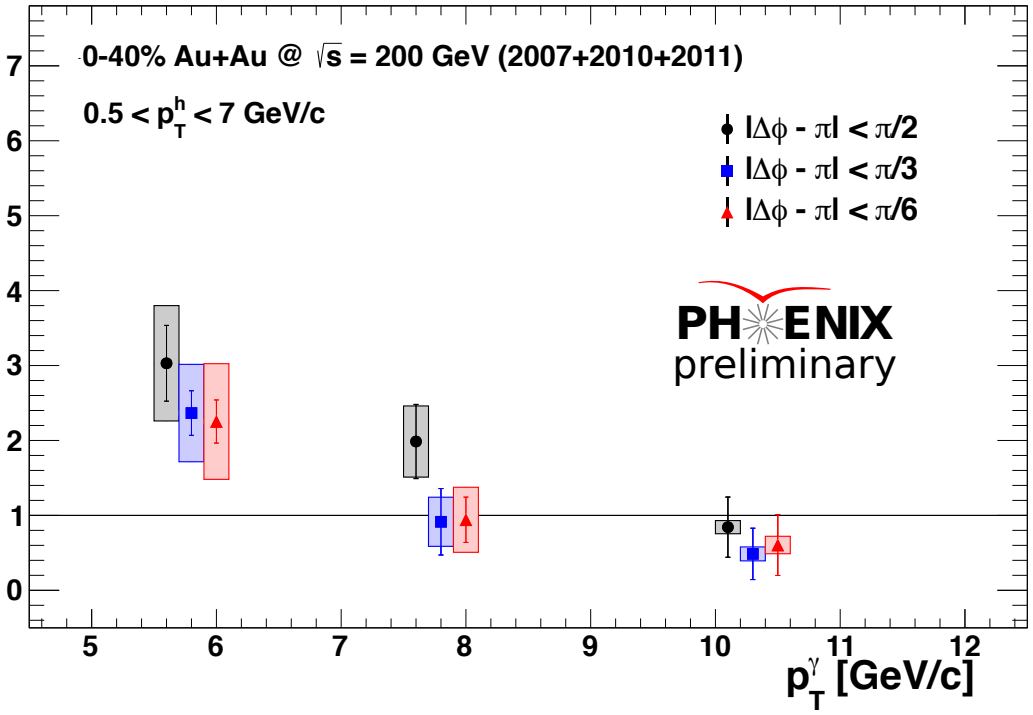
In d+Au, no significant modification to the yield is observed.

Explore Away-side Broadening in Au+Au





$$\frac{I_{AA,\xi>1.2}}{I_{AA,\xi<1.2}}$$



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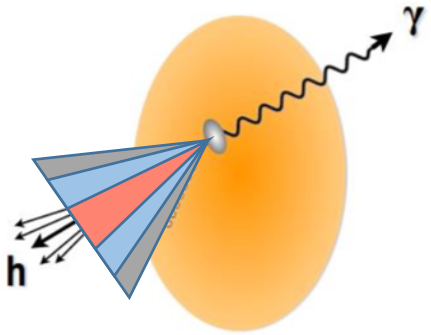
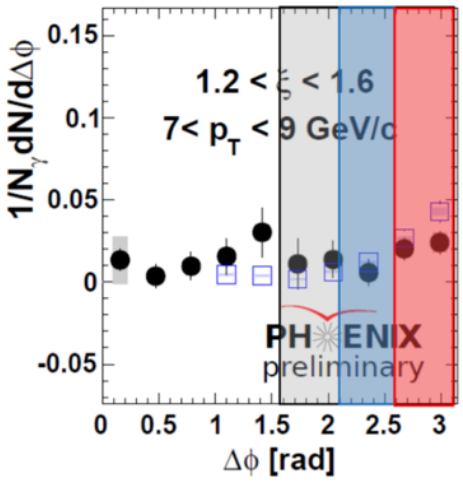
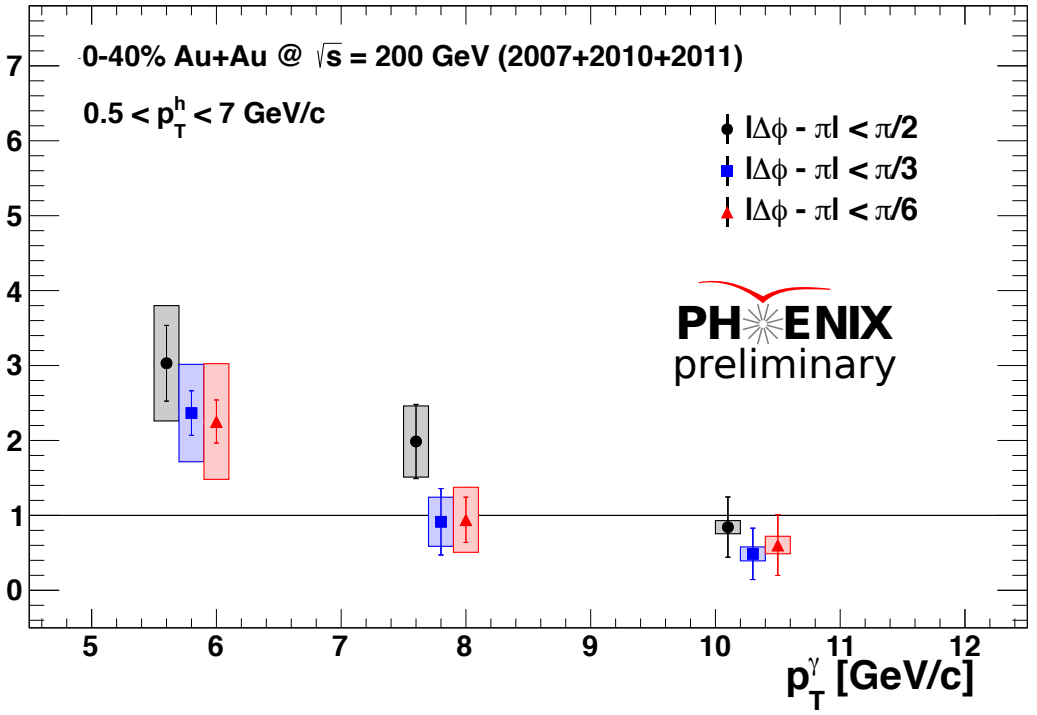




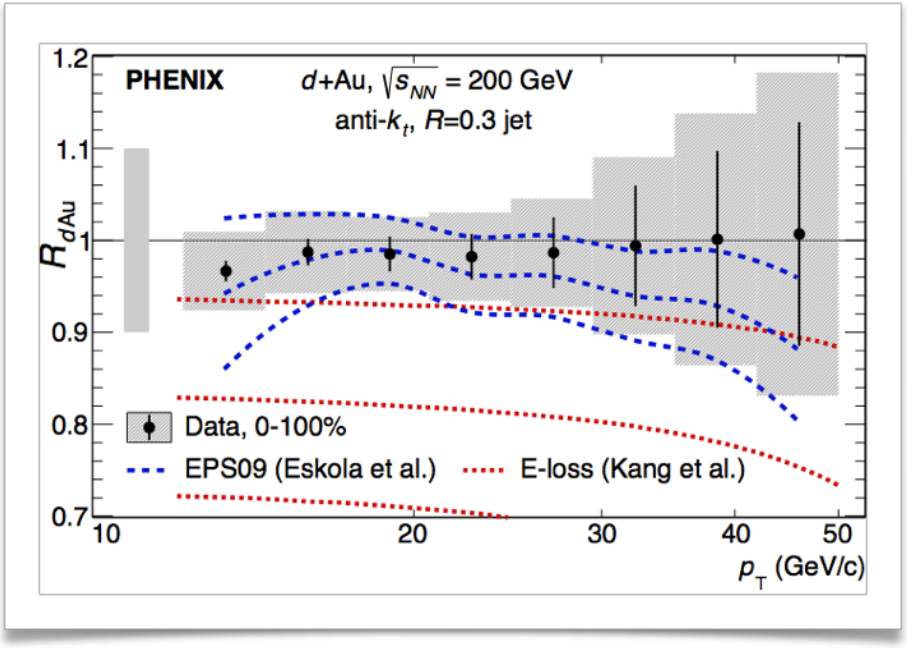
$I_{AA,\xi>1.2} / I_{AA,\xi<1.2}$



At low jet energy, slight enhancement is seen at larger opening angle. At higher jet energy, the ratio of enhancement over suppression is close to unity for all opening angle ranges.

Jets in d+Au

PHENIX PRL 116, 122301 (2016)

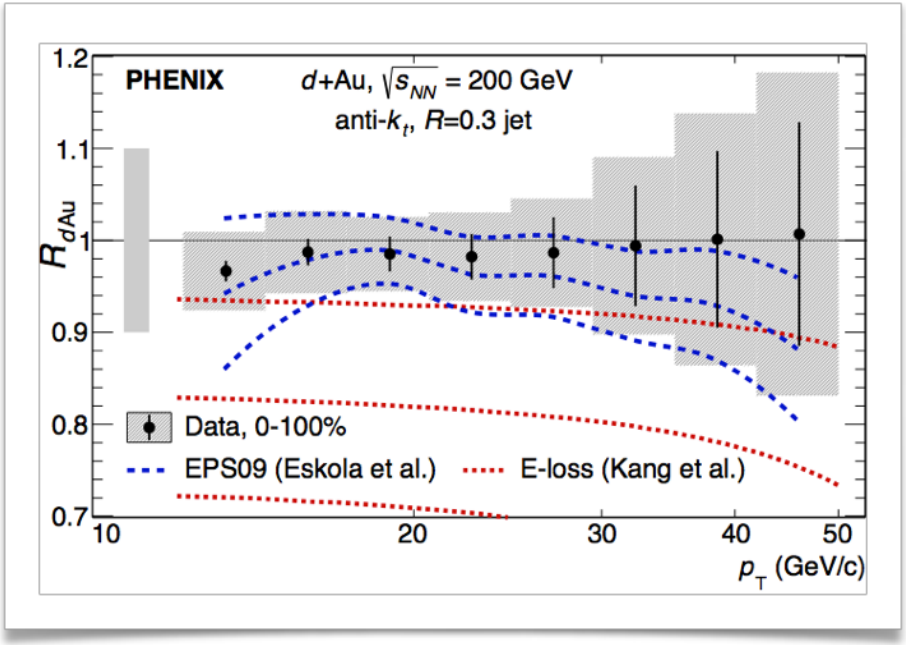


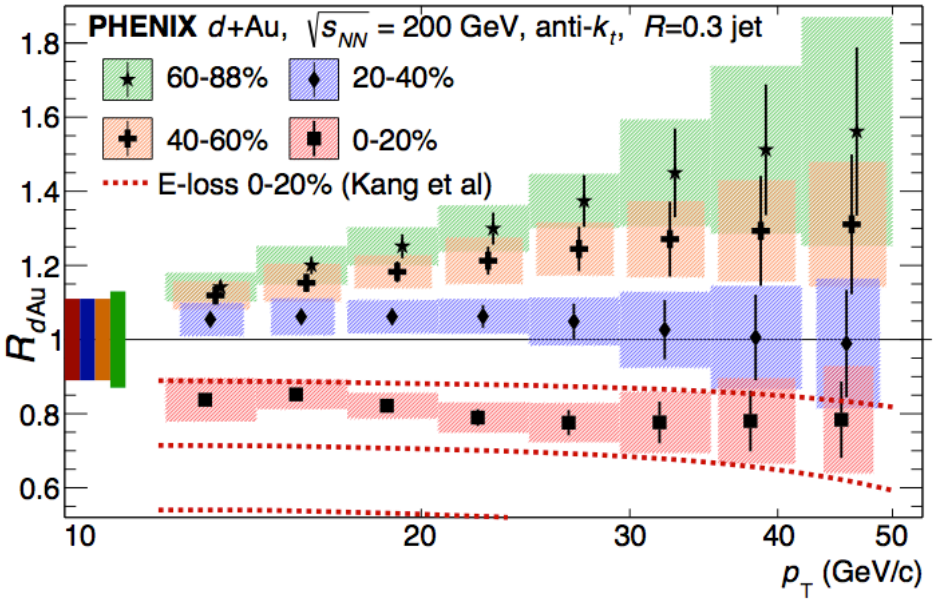
Minimum bias jets show no energy loss

See Takao Sakaguchi's talk

Jets in d+Au

PHENIX PRL 116, 122301 (2016)

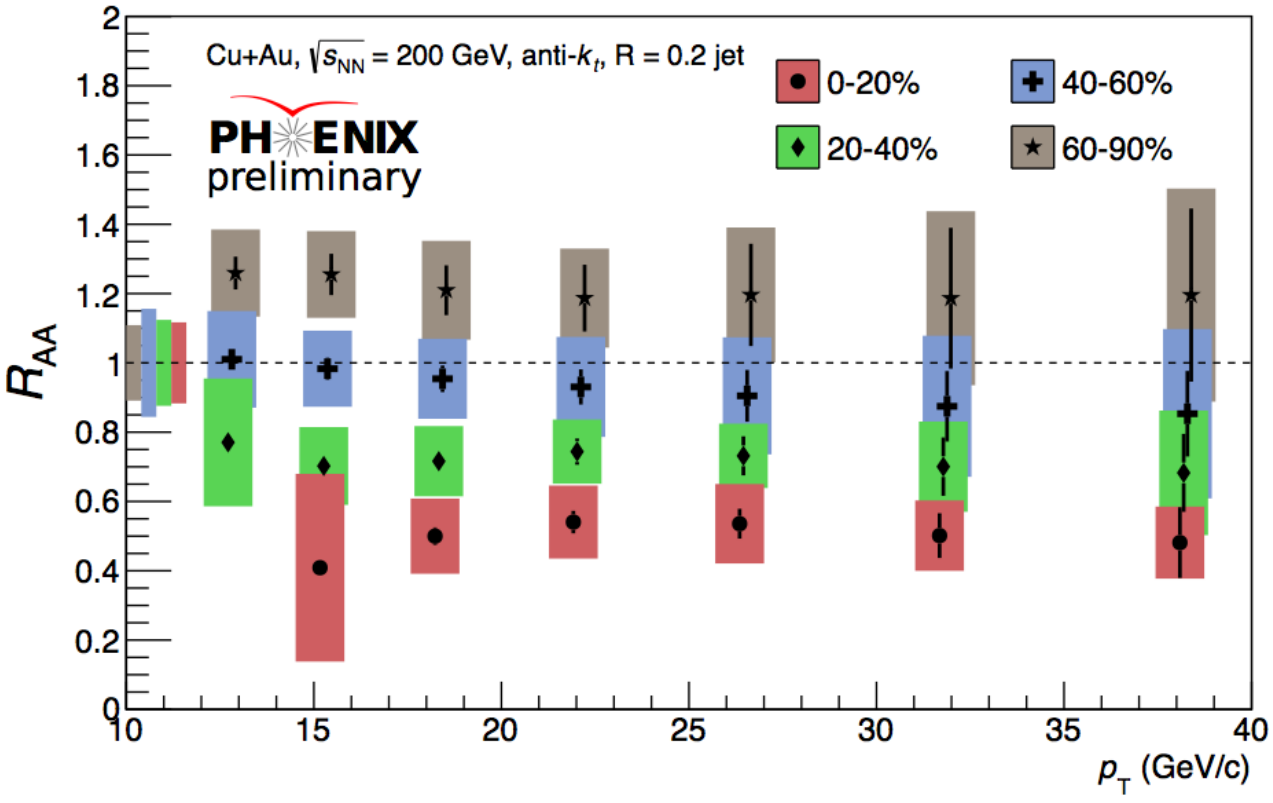




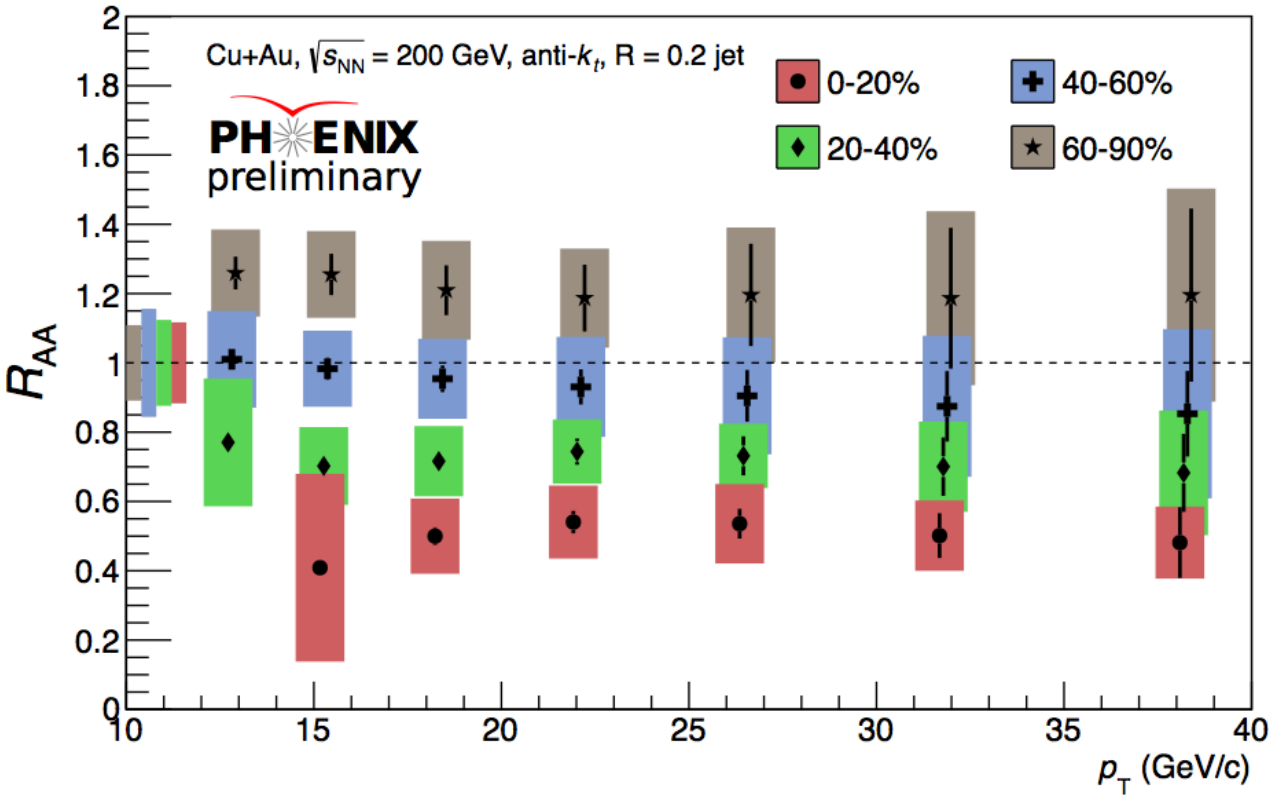
Minimum bias jets show no energy loss

- Surprising centrality dependence!
- Enhancement at high pT in peripheral collisions while suppressed in most central collisions.
- Challenge to the conventional models.

Jets in Cu+Au


Cu+Au, $\sqrt{s_{NN}}$ = 200 GeV, anti-k_t, R = 0.2 jet
PHENIX
preliminary
0-20%
20-40%
40-60%
60-90%
R_{AA}
p_T (GeV/c)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
10
15
20
25
30
35
40

Jets in Cu+Au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PHENIX
preliminary
0-20%
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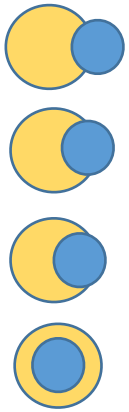
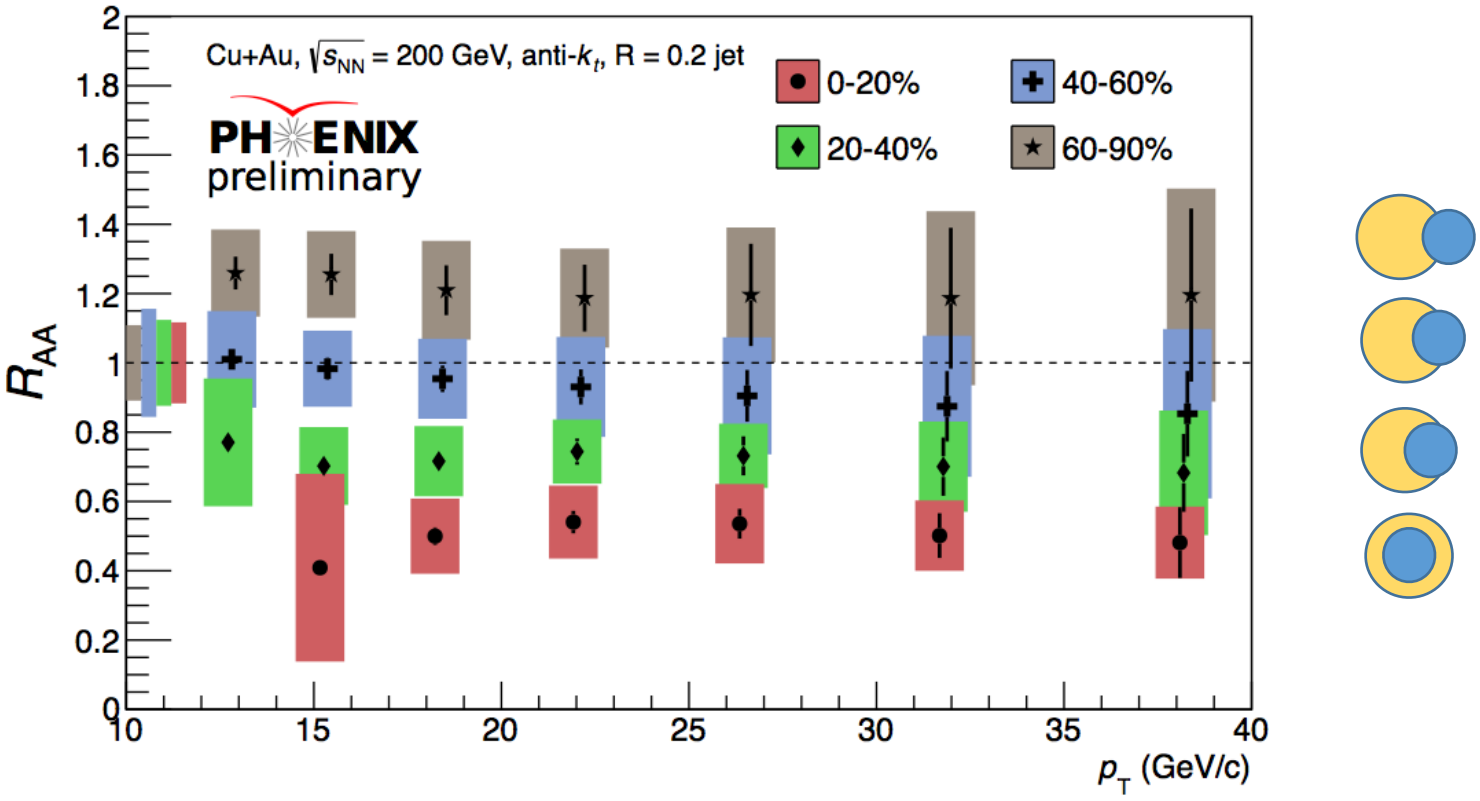
R_{AA}
p_T (GeV/c)



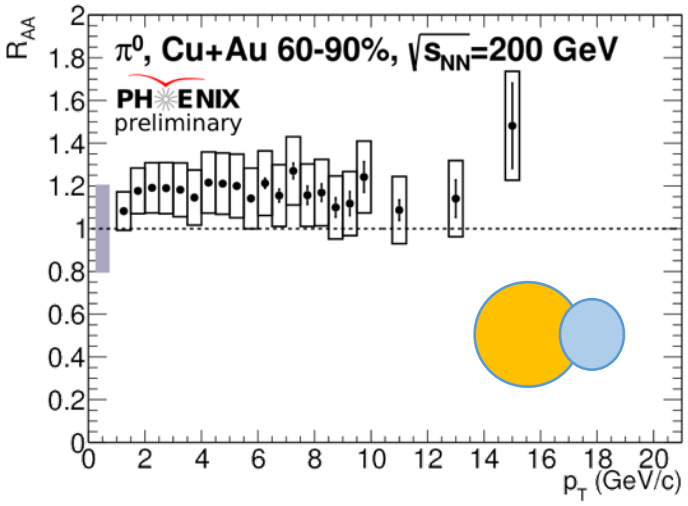
See Sergei Zharko's talk

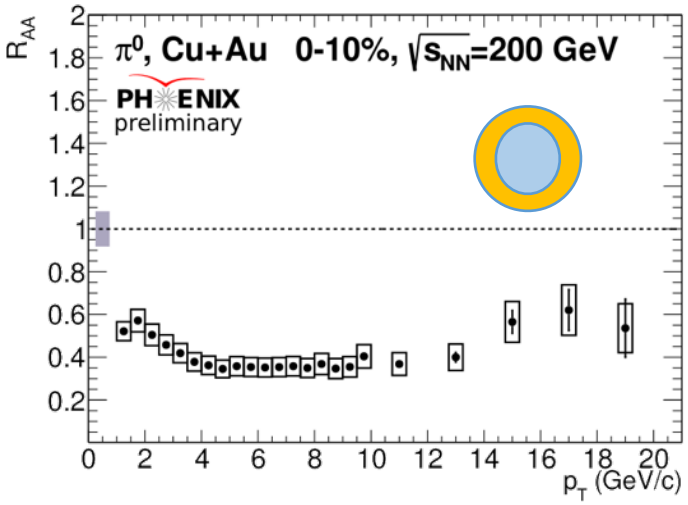
Jets in Cu+Au



- Jets suppressed by ~factor of 2 in central Cu+Au collisions.
- Suppression shows no p_T dependence, a similar trend seen from LHC experiments in Pb+Pb collisions at much higher energies.

π^0 in Cu+Au


R_{AA}
π^0, Cu+Au 60-90%, $\sqrt{s_{NN}}$=200 GeV
PHENIX
preliminary
p_T (GeV/c)


R_{AA}
π^0, Cu+Au 0-10%, $\sqrt{s_{NN}}$=200 GeV
PHENIX
preliminary
p_T (GeV/c)

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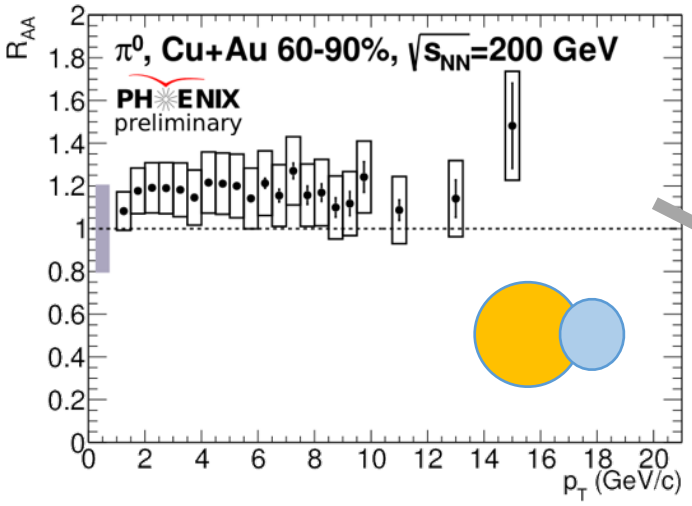
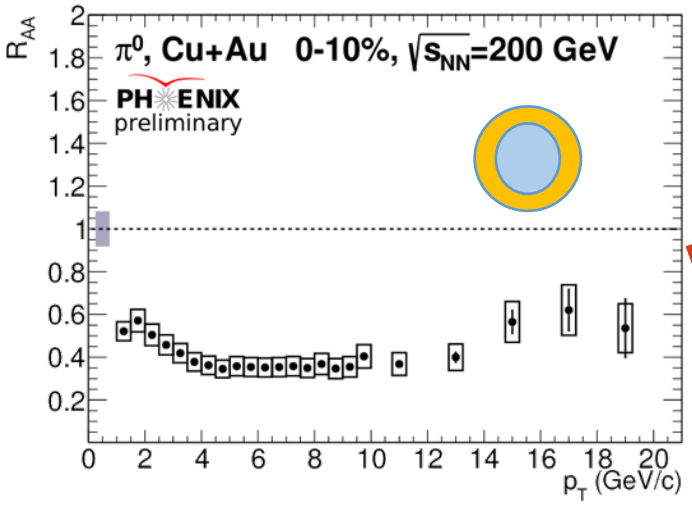
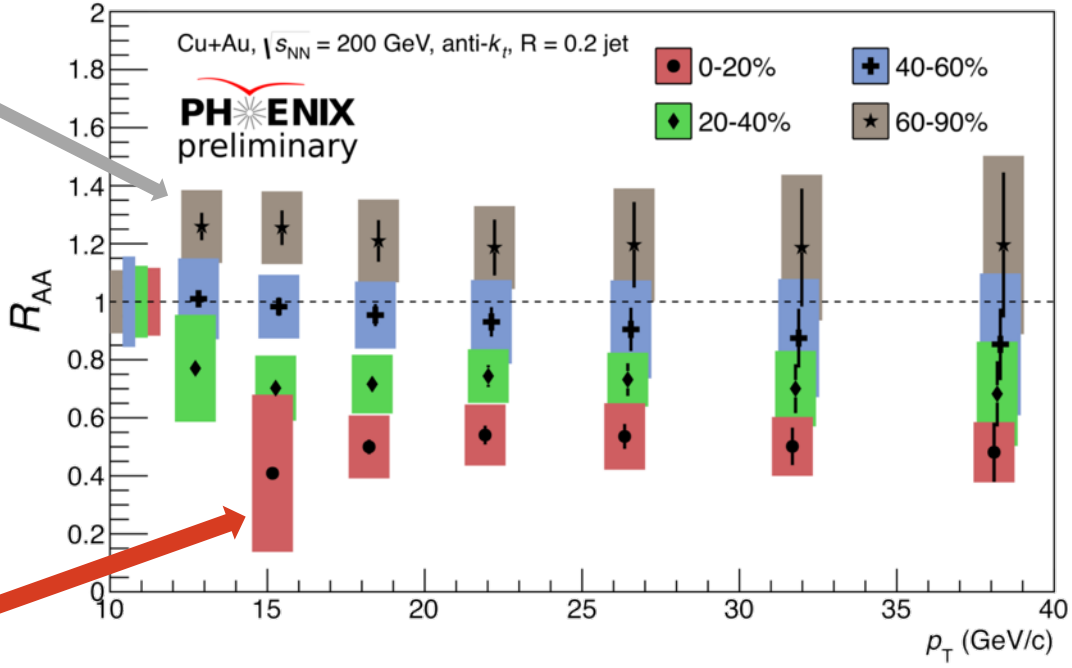
π^0 in Cu+Au



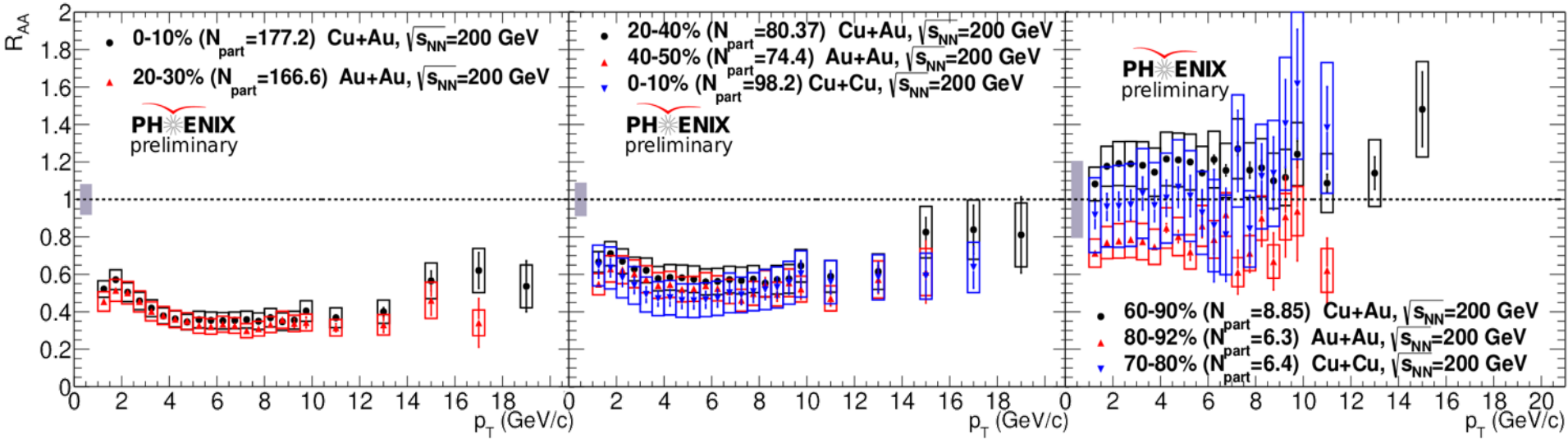




π^0 results and jet measurement in Cu+Au seem showing the consistent trend!

π^0 R_{AA} in Cu+Au, Cu+Cu and Au+Au

Phys. Rev. Lett. 101, 232301 Phys. Rev. Lett. 101, 162301



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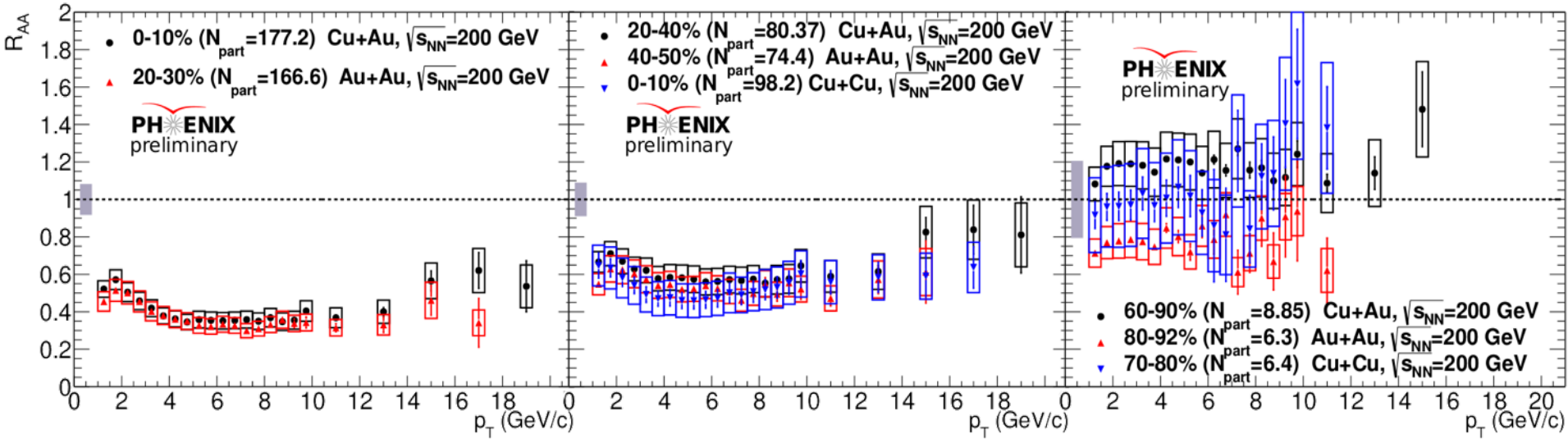
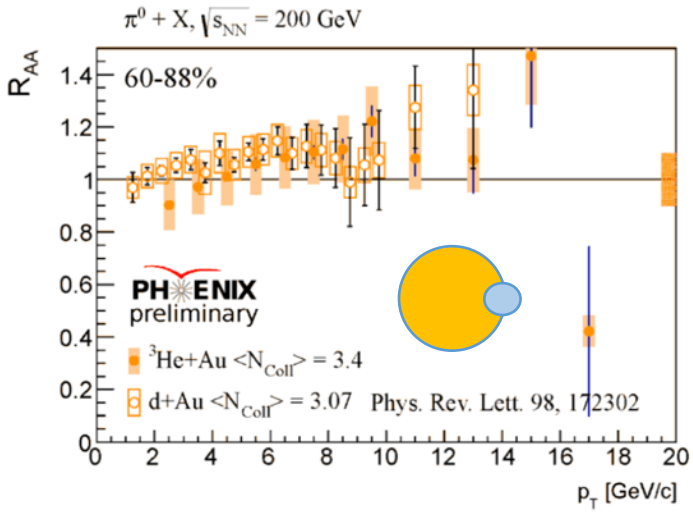
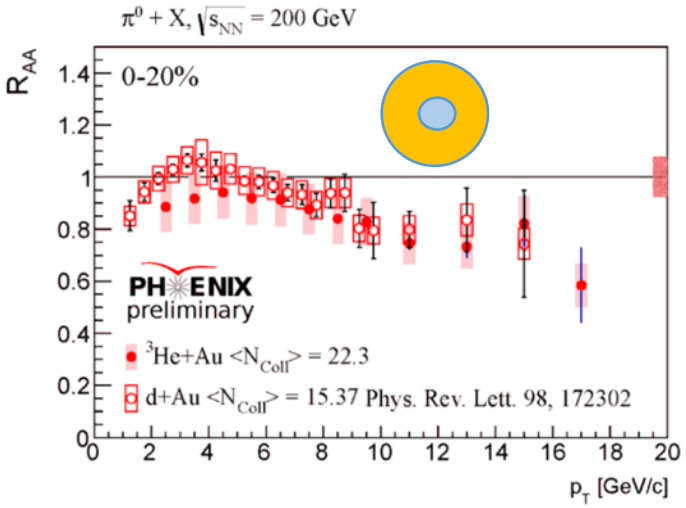
Phys. Rev. Lett. 101, 232301 Phys. Rev. Lett. 101, 162301



- In central and semi central Cu+Au collisions π^0 yields are suppressed similar to Cu+Cu and Au+Au.
- In peripheral Cu+Au collisions, π^0 yields show a hint on enhancement, while suppression in Au+Au, Cu+Cu lies in the middle.

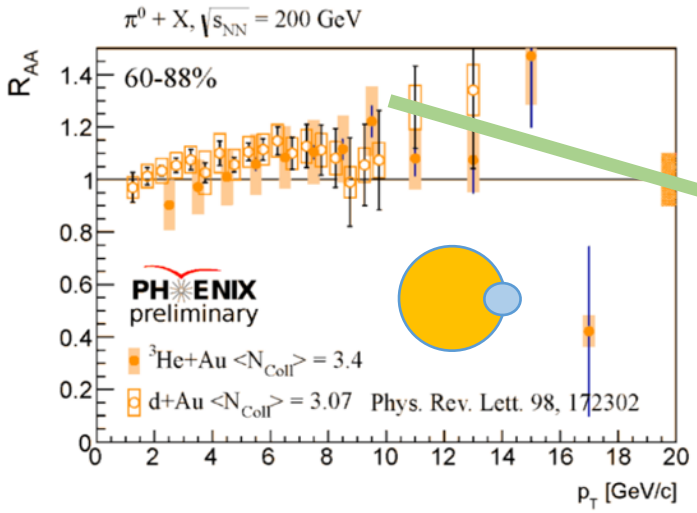
π^0 in ^{3}He+Au

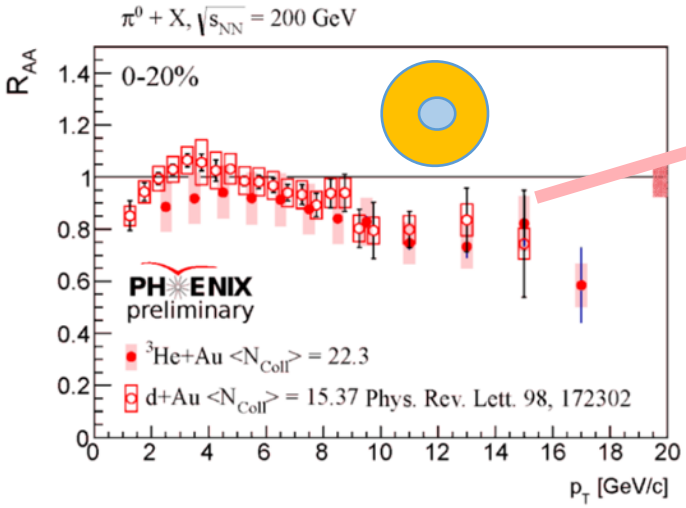

π^0 + X, $\sqrt{s_{NN}}$ = 200 GeV
R_{AA}
60-88%
PHENIX
preliminary
^{3}He+Au <N_{Coll}> = 3.4
d+Au <N_{Coll}> = 3.07 Phys. Rev. Lett. 98, 172302
p_T [GeV/c]

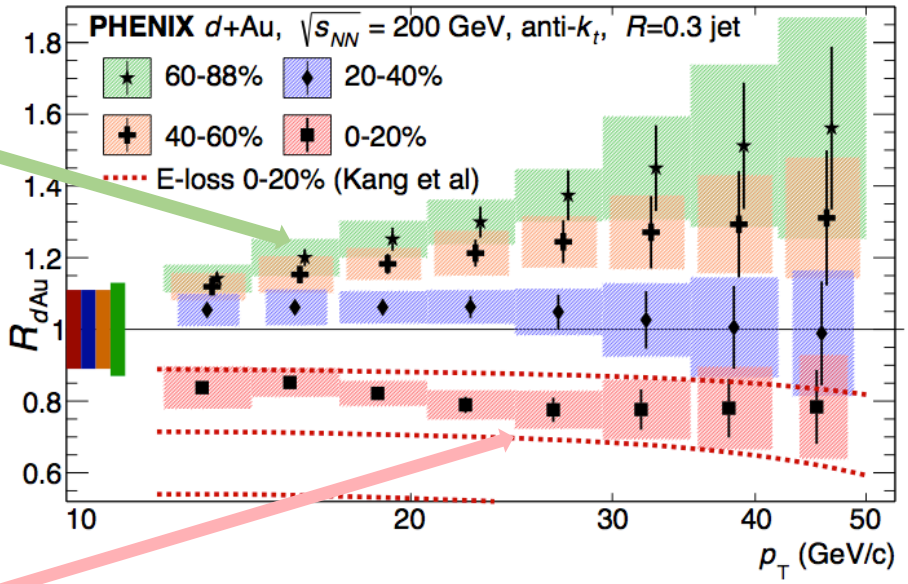

π^0 + X, $\sqrt{s_{NN}}$ = 200 GeV
R_{AA}
0-20%
PHENIX
preliminary
^{3}He+Au <N_{Coll}> = 22.3
d+Au <N_{Coll}> = 15.37 Phys. Rev. Lett. 98, 172302
p_T [GeV/c]

See Takao Sakaguchi's talk

π^0 in ^{3}He+Au



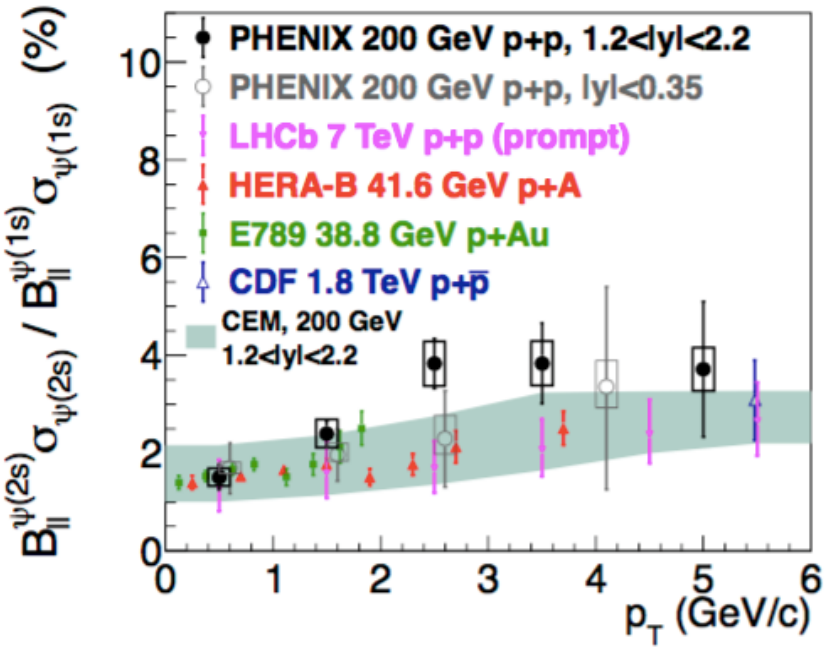




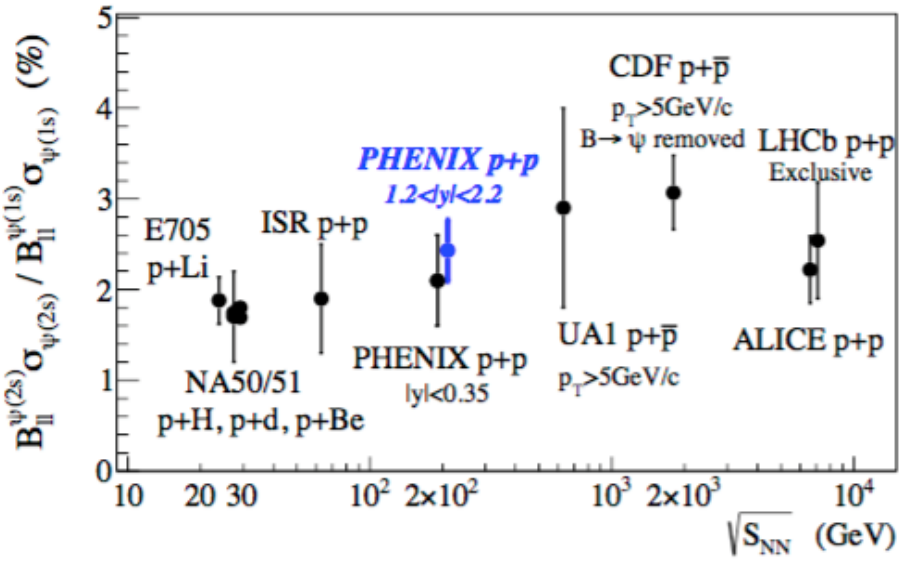
Again, π^0 results and jet measurement in d+Au seems showing the consistent trend!

Heavy Flavor Measurements

Relative Yields of Ψ(2S) and Ψ(1S) Production in Forward and Backward Rapidity in p+p



PHENIX: arXiv:1609.06550



See Axel Drees's talk

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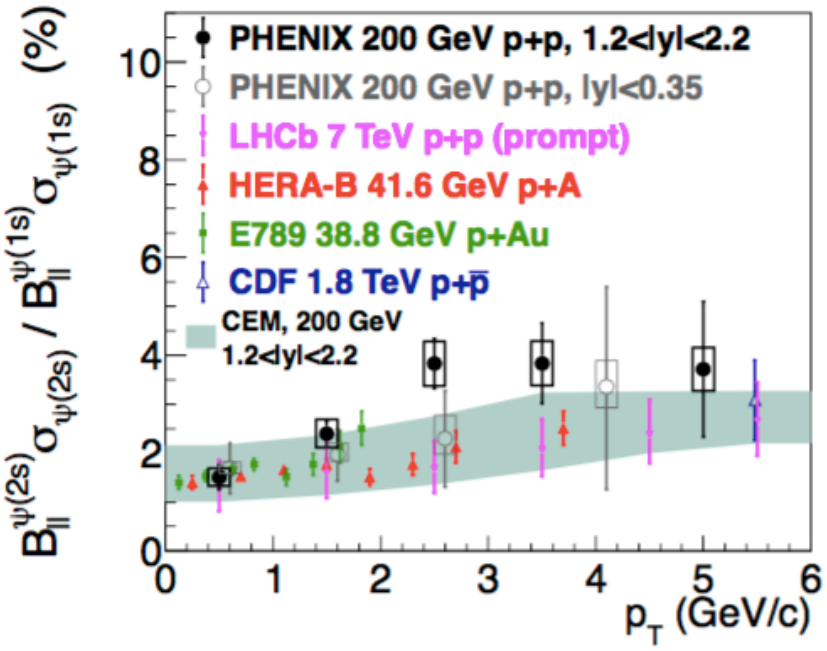

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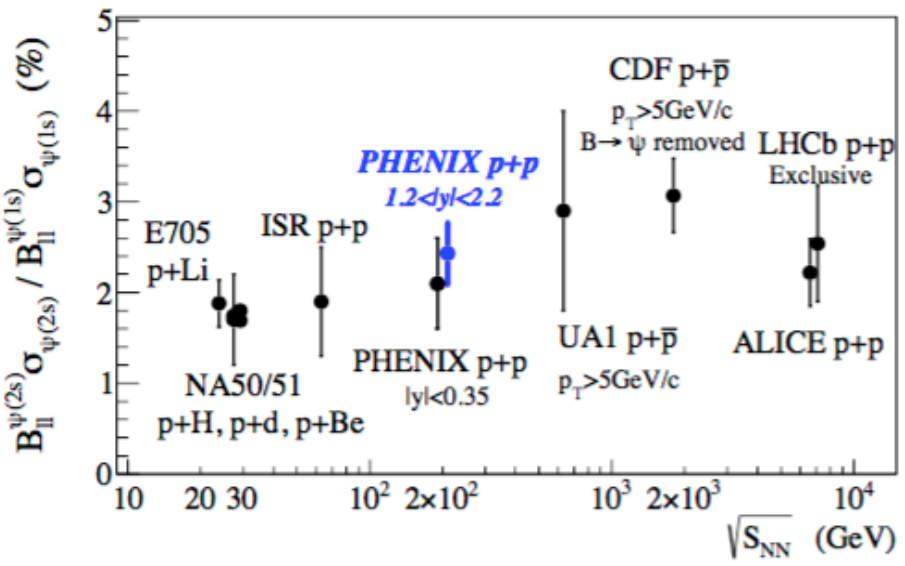
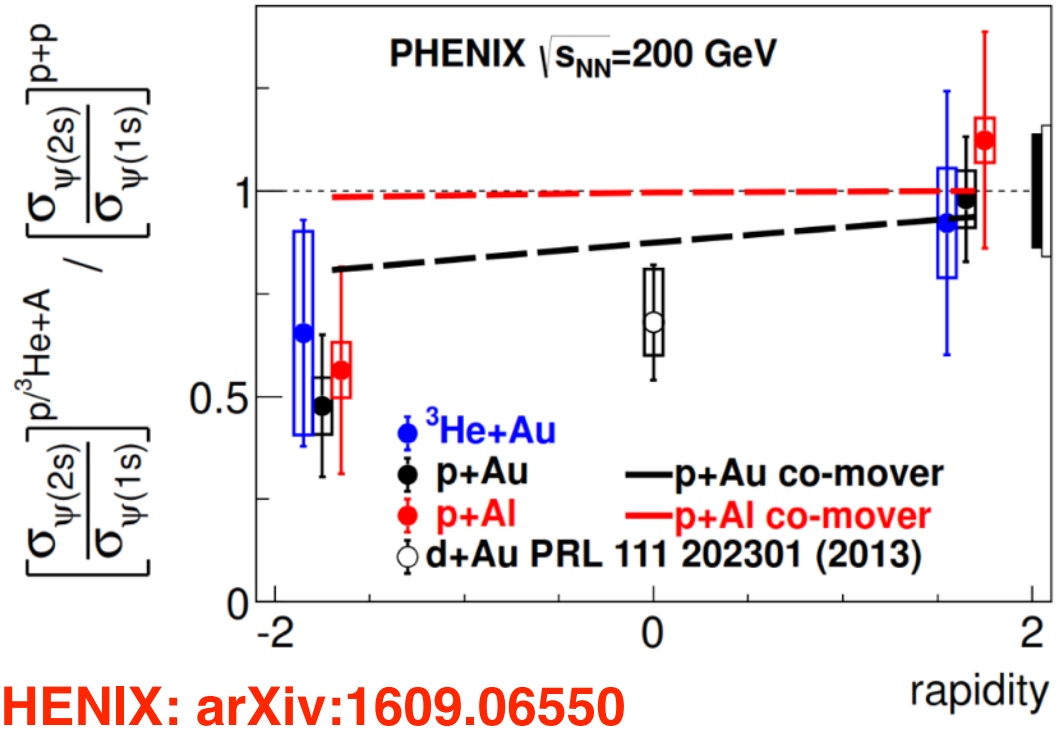


- The ratio in p+p is consistent with other measurements.
- This provides the baseline for suppression measurements in p+Al, p+Au and He+Au collisions.

Measurement of the relative yields of Ψ(2S) and Ψ(1S) produced at forward and backward rapidity in p+Al, p+Au and ^{3}He+Au collisions.



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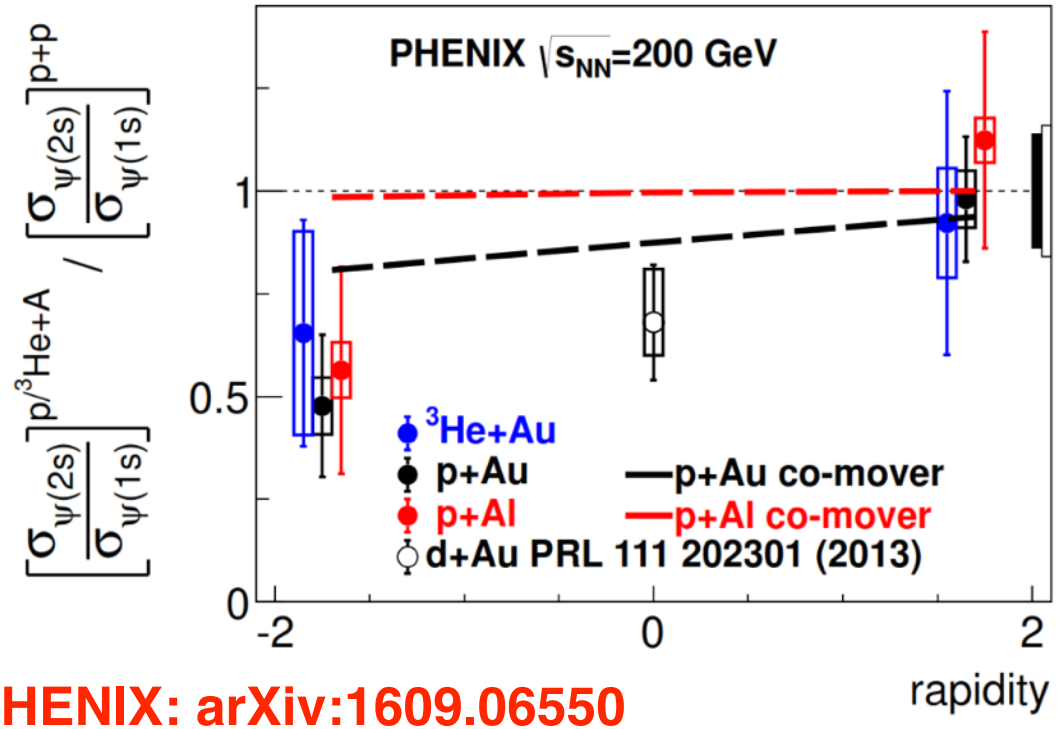

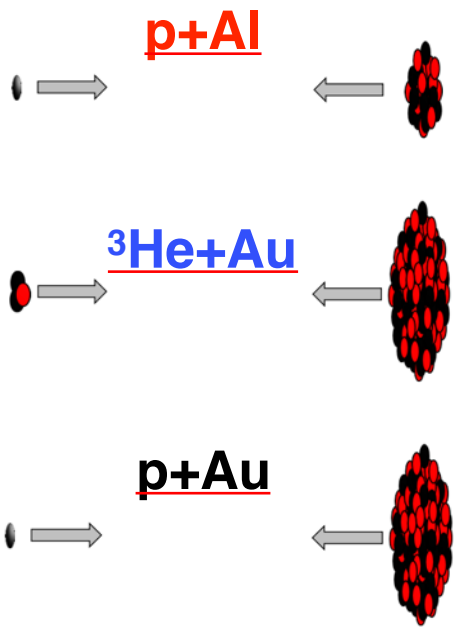

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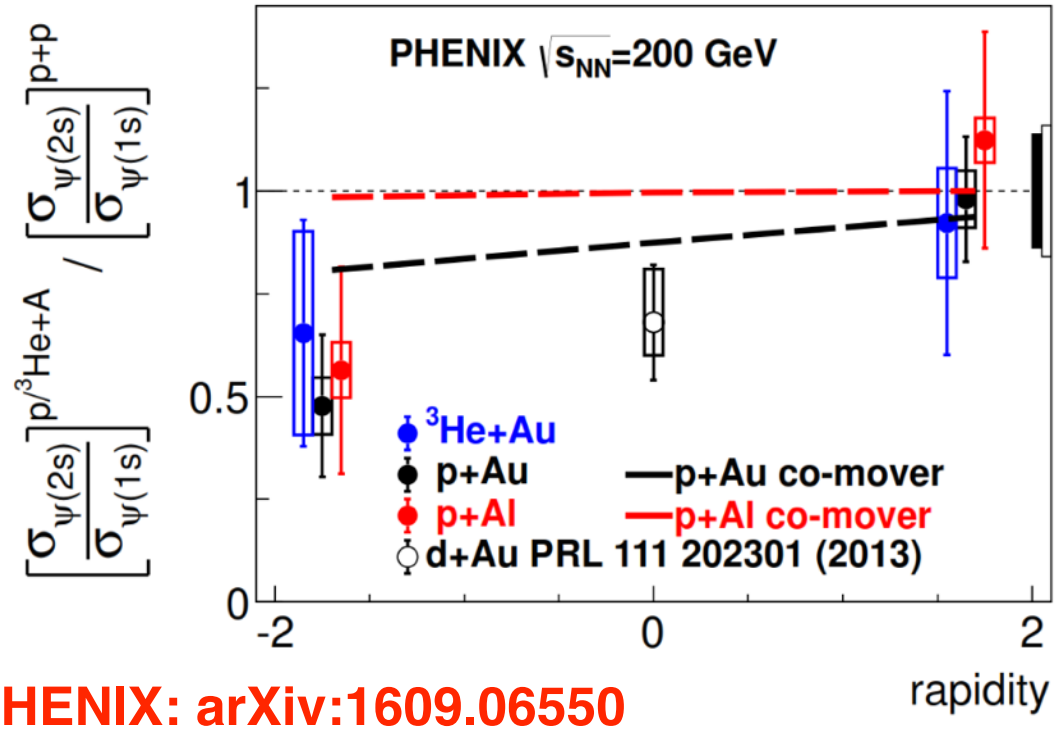

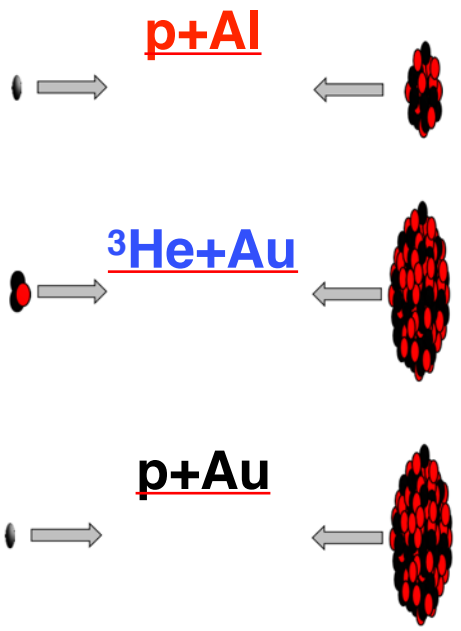

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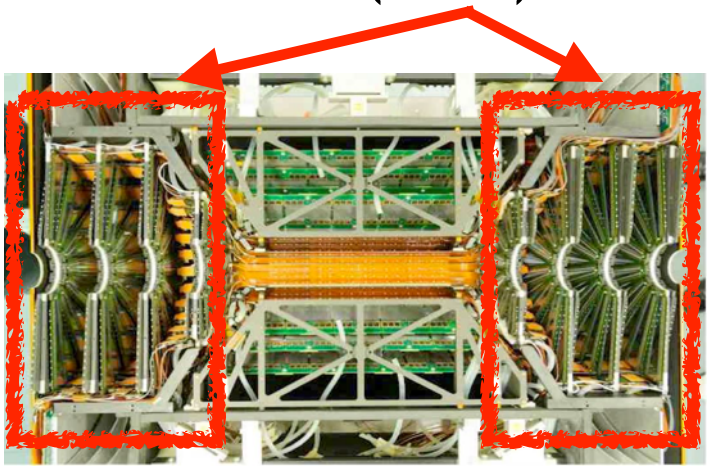
The double ratios are consistent with unity in all three collision systems for forward rapidity. At backward rapidity, the ratios are suppressed by a factor 2 in all systems .

B->J/ψ in p+p at 510 GeV

B —>J/ψ fraction was measured by precise measurement of distance of closest approach in the plane perpendicular to the beam using forward silicon vertex detector (FVTX)



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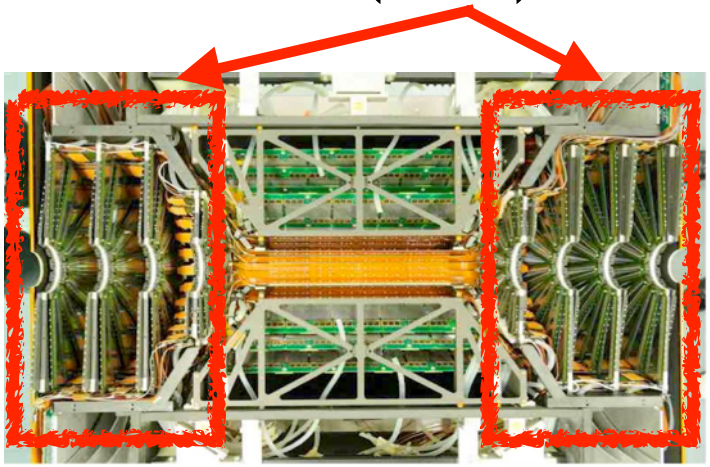

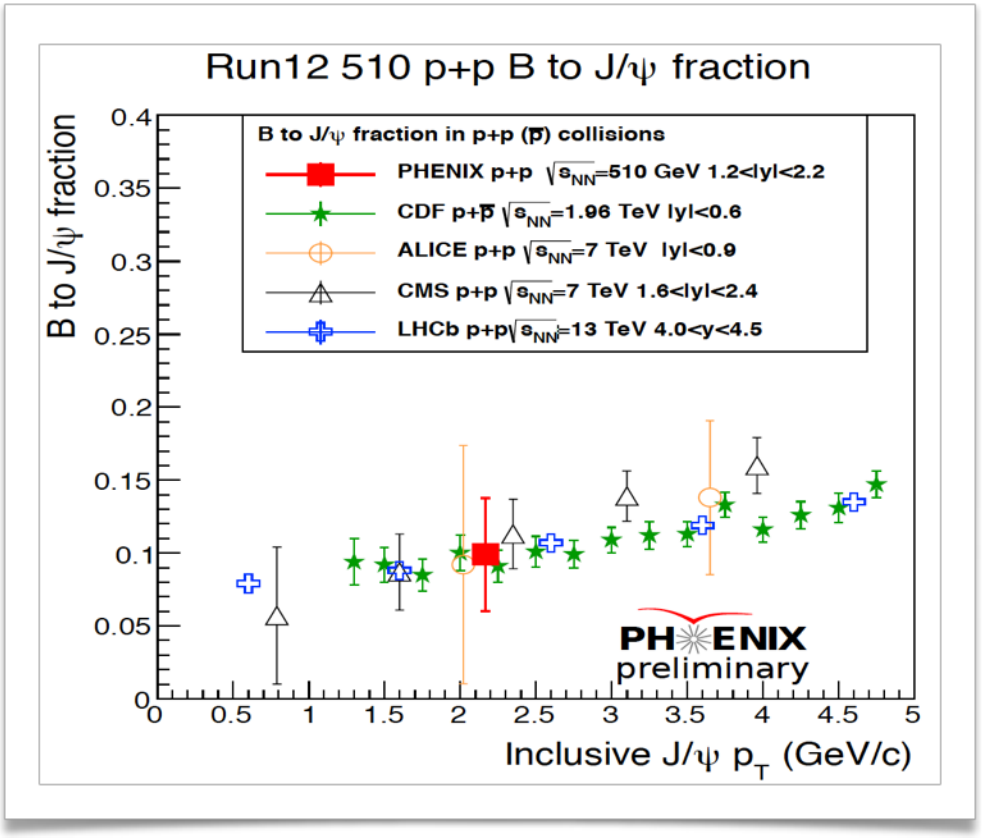

See Cesar da Silva's talk

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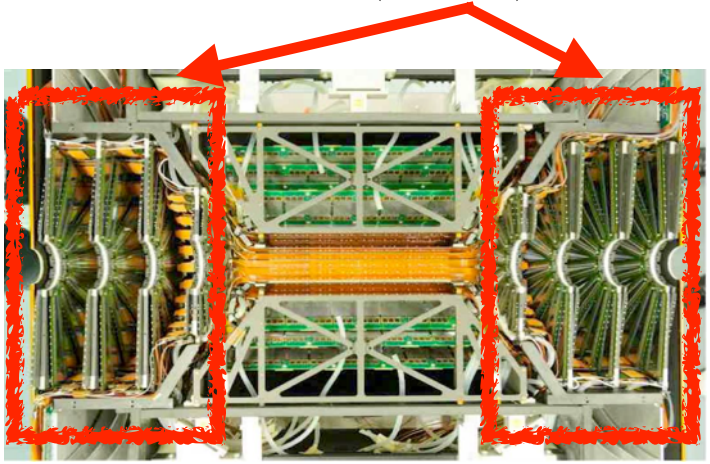
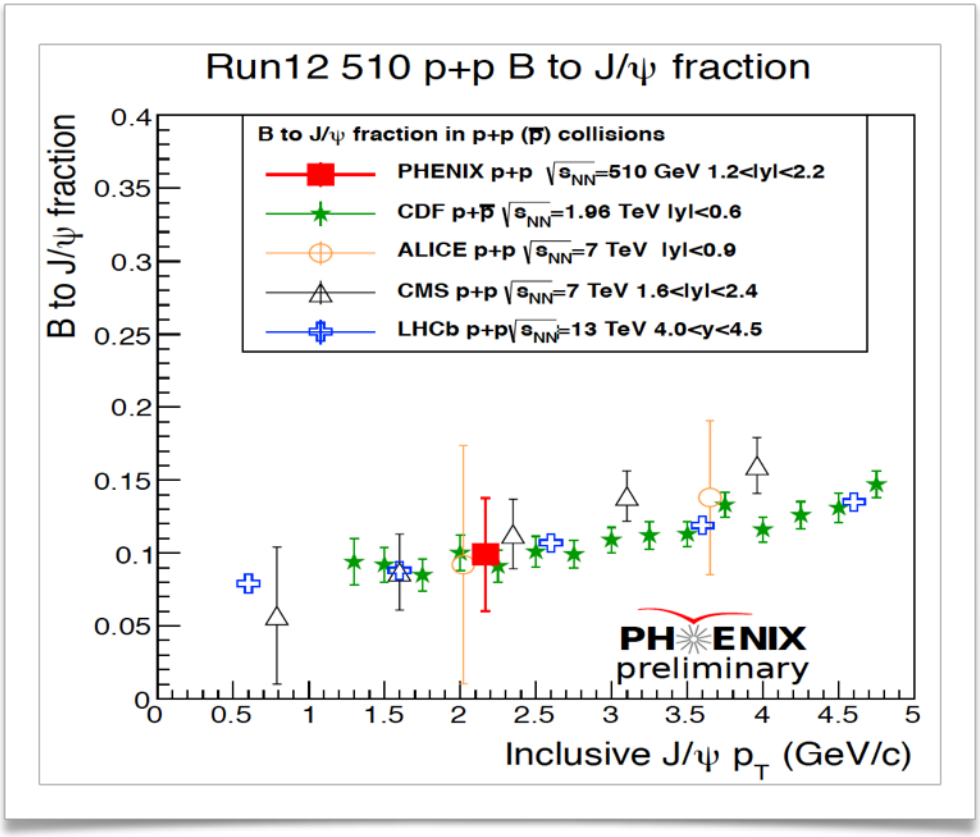
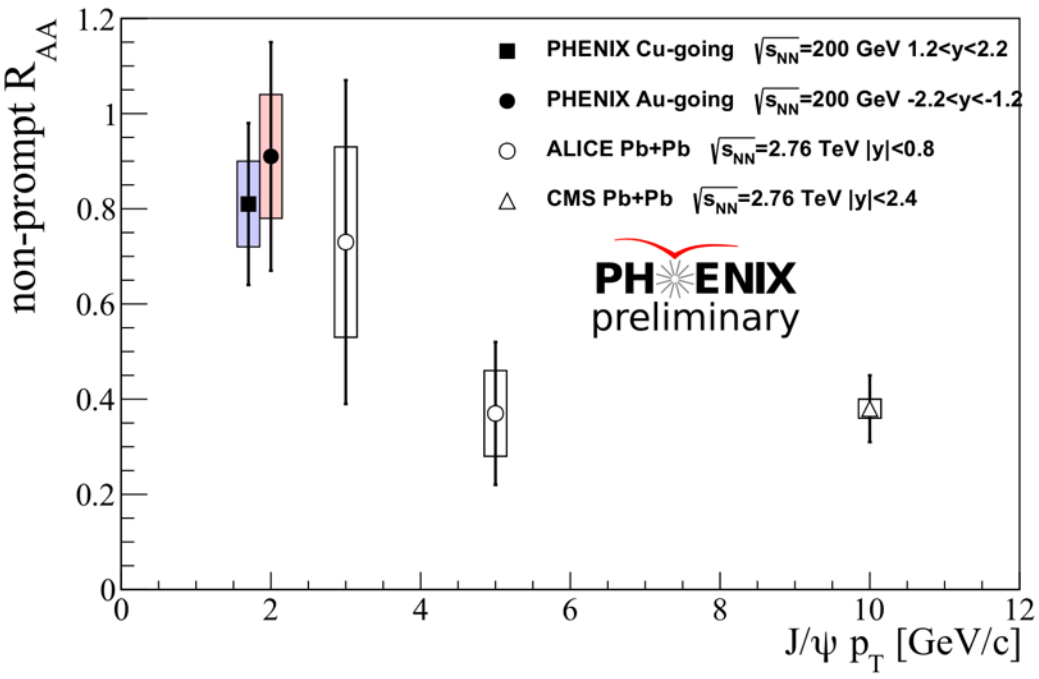




The fraction is consistent with other measurements at different energies.

B->J/ψ in Cu+Au at 200 GeV

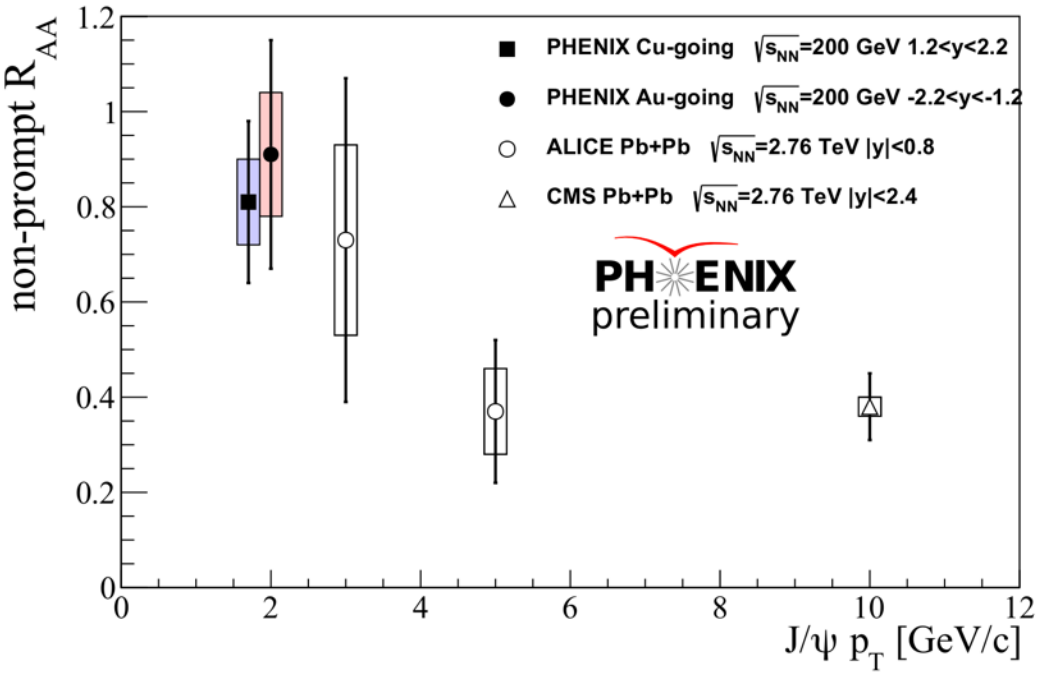


No pp reference at 200 GeV at this moment. Using $F_{B/J\psi}$ (pp)=0.1, consistent to the world p+p data at p_T=1.5 GeV/c.

$$R_{AA}^{B\to J/\psi} = \frac{F_{B\to j/\psi}^{AA}}{F_{B\to j/\psi}^{pp}} R_{AA}^{J/\psi} = \frac{F_{B\to j/\psi}^{AA}}{0.1} R_{AA}^{J/\psi}$$

See Cesar da Silva's talk

B->J/ψ in Cu+Au at 200 GeV



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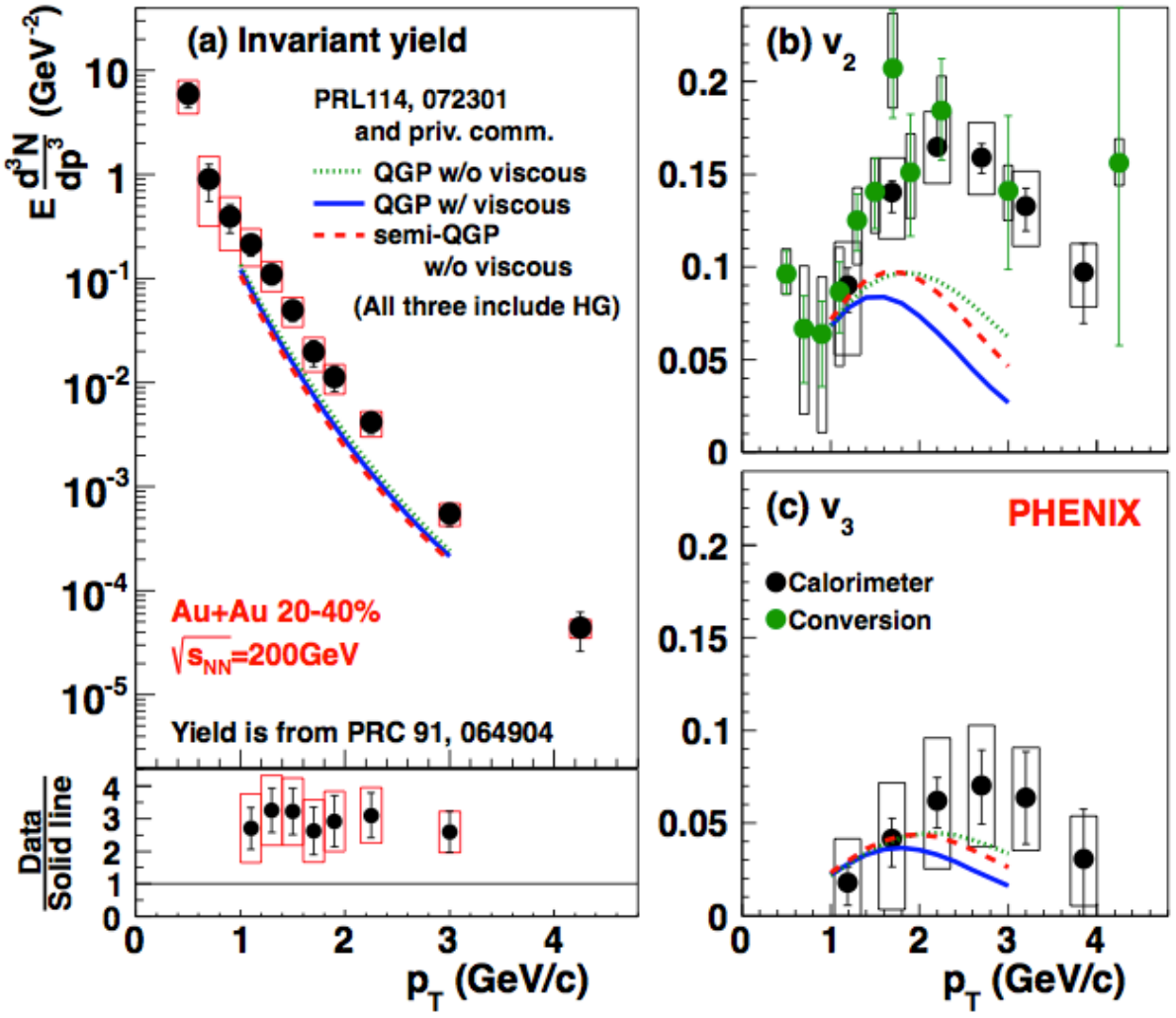
Momentum and centrality integrated B-meson measurements in Cu+Au collisions consistent with no nuclear modification.

Direct Photon and Flow in Small Systems

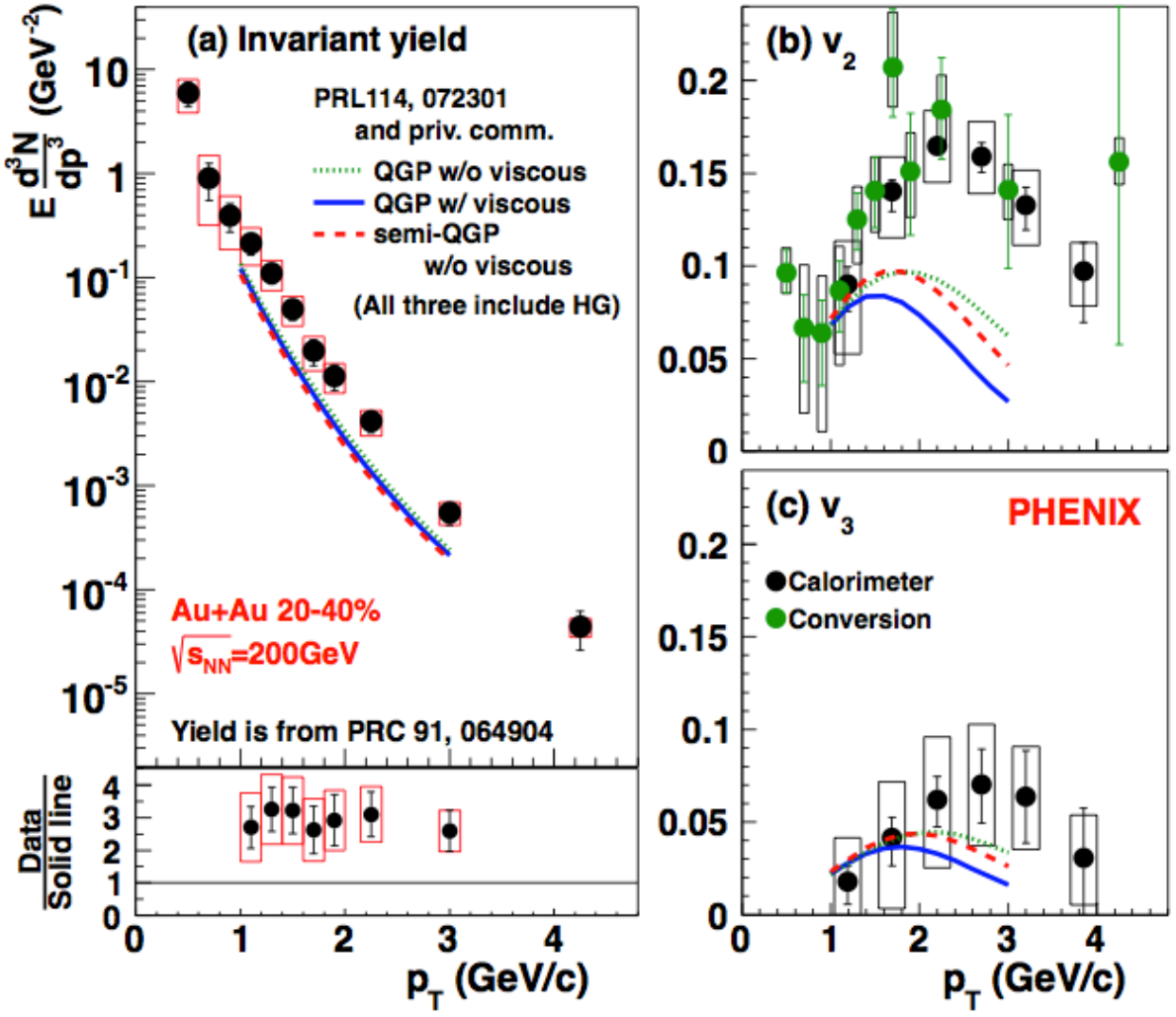
Shining Photons FLOW in Au+Au



arXiv:1509.07758

See Wenqing Fan's talk

Shining Photons FLOW in Au+Au



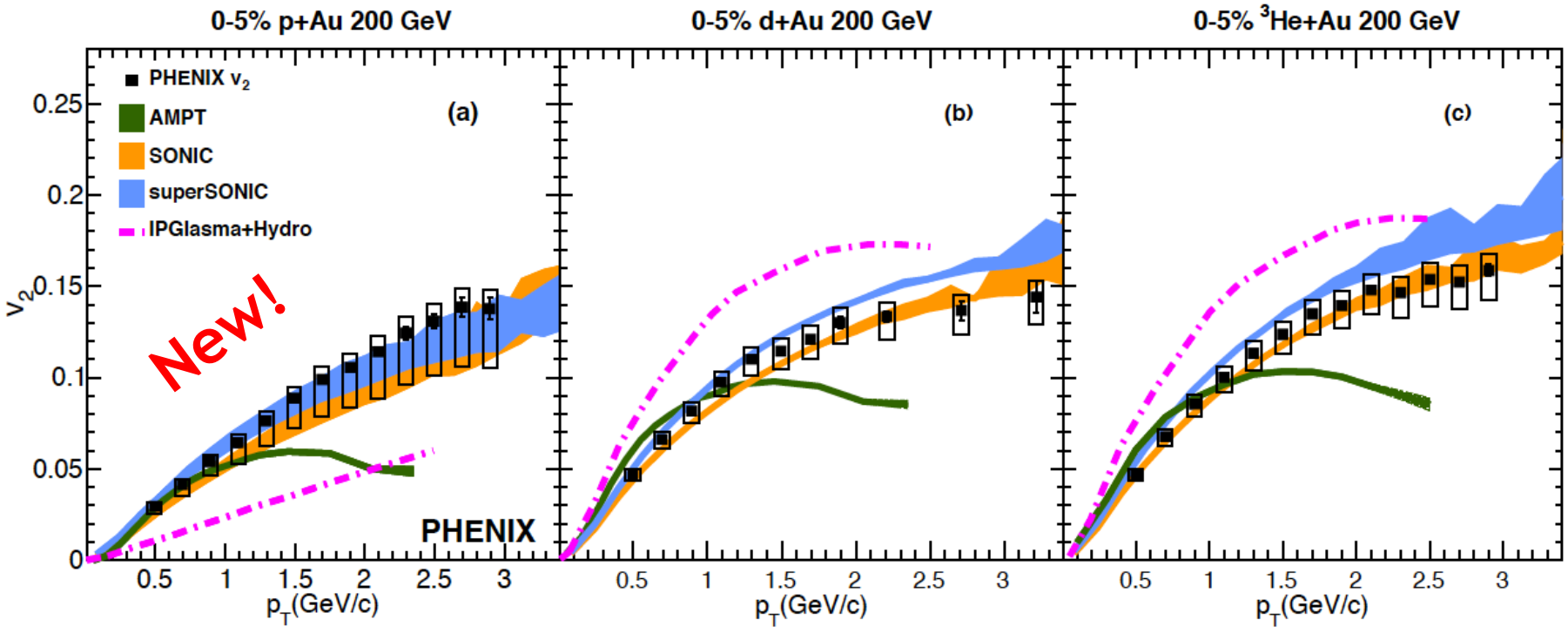
arXiv:1509.07758

A sizable v2 and v3 are observed for direct photons.

Theoretical picture still incomplete to describe large yield and v2 simultaneously.

p+Au Flow

PHENIX: arXiv:1609.02894



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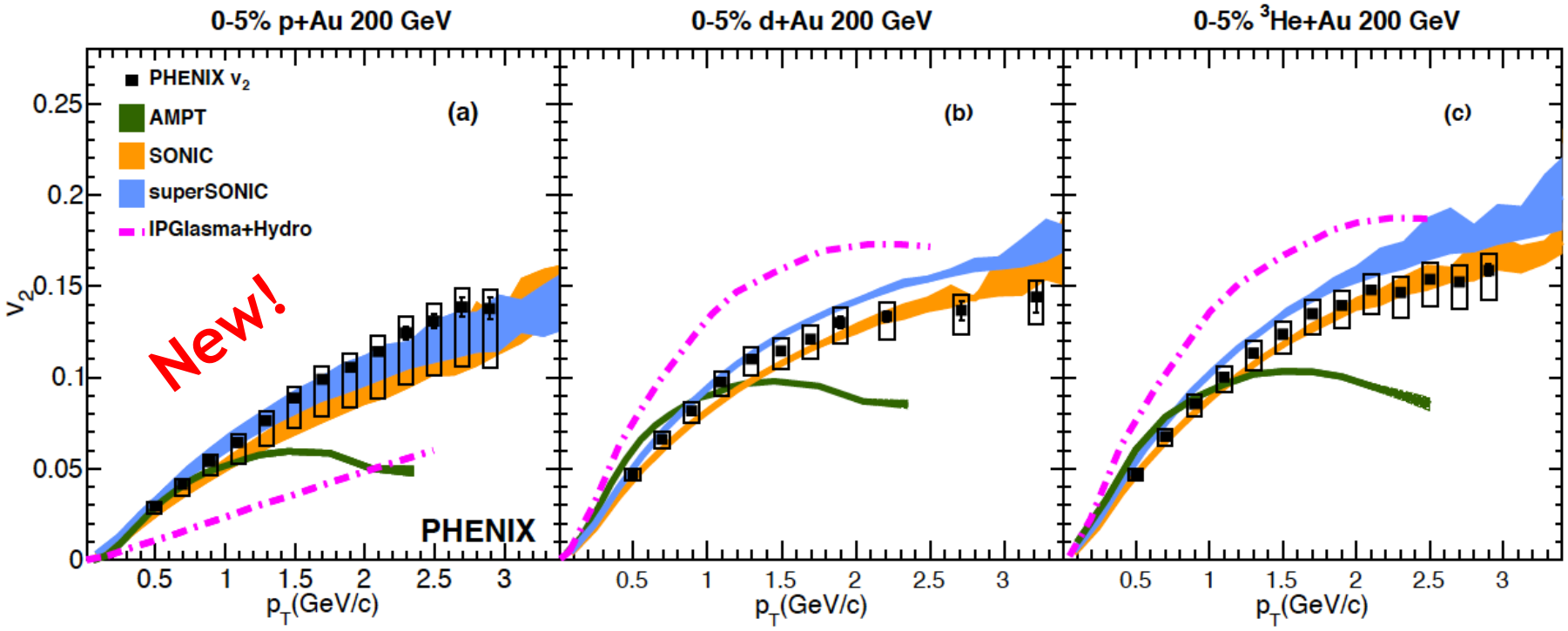

- Observation of v2 in central p+Au at RHIC energy
- Hydro-model seem reproduce the v2 in p+Au, d+Au, and He+Au
- Does direct photon flow in small system?

Summary

- There is a suite of new PHENIX results since the last Hard Probe conference. Please go and listen to the six parallel talks from PHENIX for details.
- PHENIX is emptying its nest for a brand new experiment, sPHENIX, focusing on the precision measurements of jet tomography in QGP and upsilon melt.
- PHENIX offline data production and analyses are ongoing. Stay tuned for more groundbreaking results from PHENIX.

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THANK YOU !!!

PHENIX Parallel Talks at HP2016

- Direct Photon Production and Azimuthal Anisotropy at Low Transverse Momentum Measured in PHENIX – Wenqing Fan (9/24)
- Relative Yields and Nuclear Modification of Psi' to J/Psi mesons in p+p, p(3He)+A Collisions at sqrt(s_NN) = 200 GeV, measured in PHENIX – Axel Drees (9/25)
- Nuclear Modification of B mesons in Cu+Au Collisions at 200 GeV measured through the B-> J/psi decay by the PHENIX Experiment– Cesar de Silva (9/24)
- Hard Probe Measurements in Cu+Au Collisions at PHENIX: Jets and Leading Particles – Sergey Zharko (9/24)
- PHENIX results on direct photon-hadron correlations – Huijun Ge (9/24)
- Jet and Leading Hadron Production in d+Au Collisions in the PHENIX Experiment - Takao Sakaguchi (9/24)

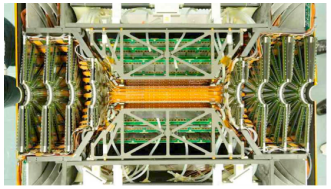
Backups

- Jet production and modification in QCD matter
- High *p*T hadron spectra and correlations
- Jet-induced medium excitations
- Jet properties in small systems
- Heavy flavor hadrons and quarkonia
- Photons and dileptons
- Initial state and related topics

What is NEW at HP2016?

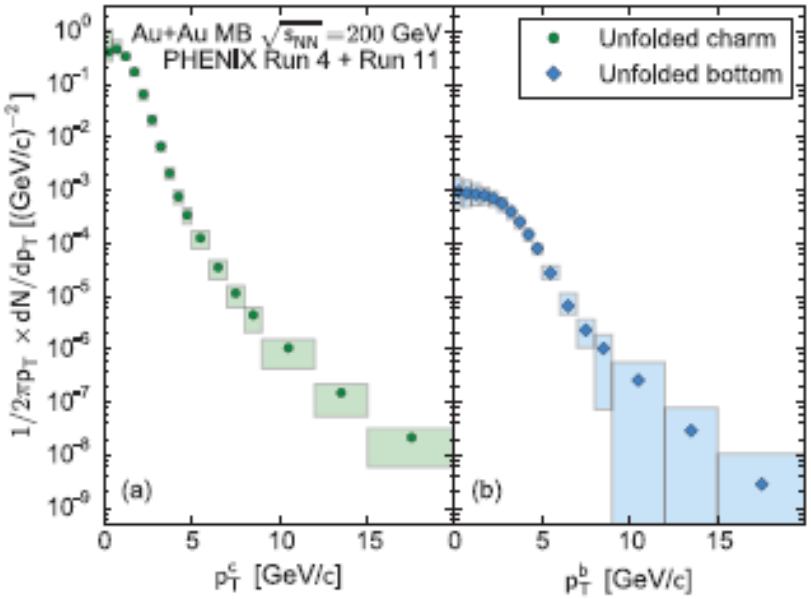
Getting to the heart of QGP matter and dissecting the signals in the uncharted physics realm

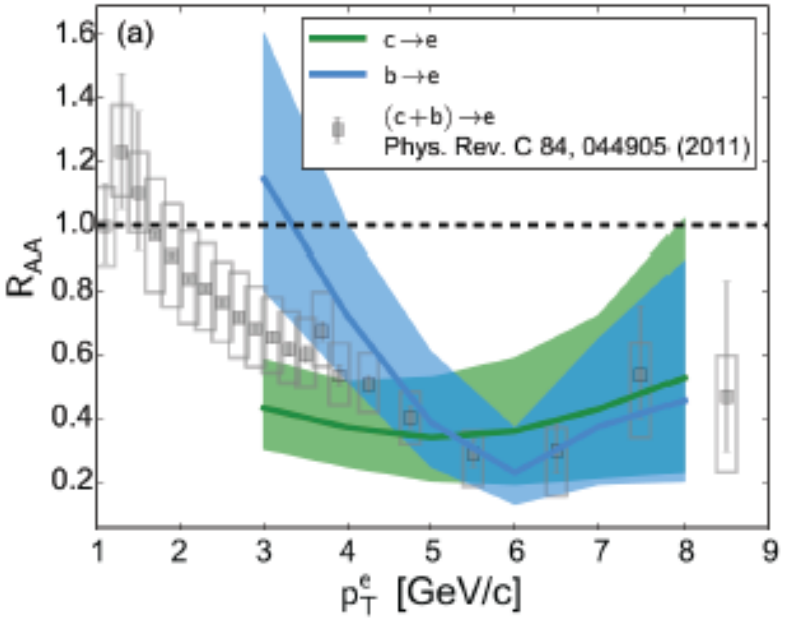
R_{AA} for electrons from c and b



Unfolding to obtain b/(c+b) electron fraction in Au+Au
Combine with previous results in pp from correlation analysis

Phys. Rev. C93, 034904 (2016)





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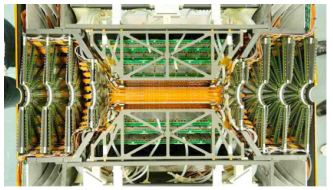

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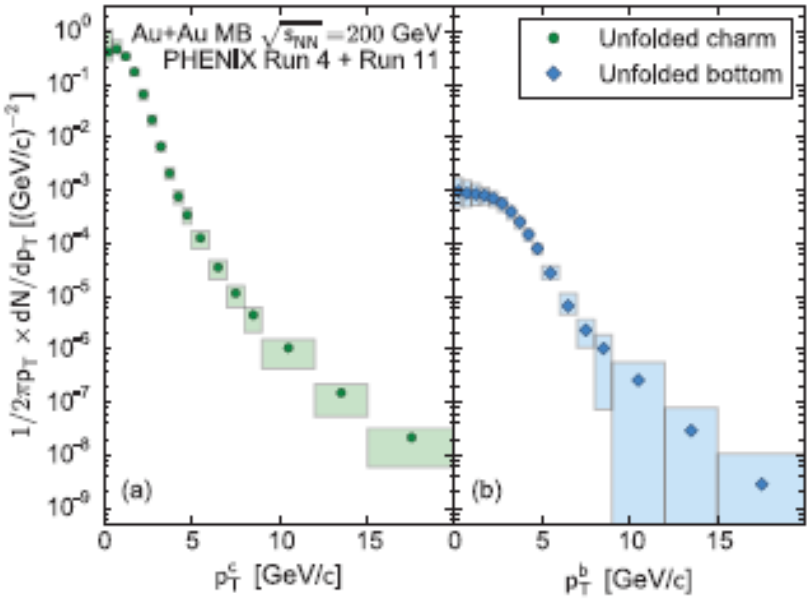

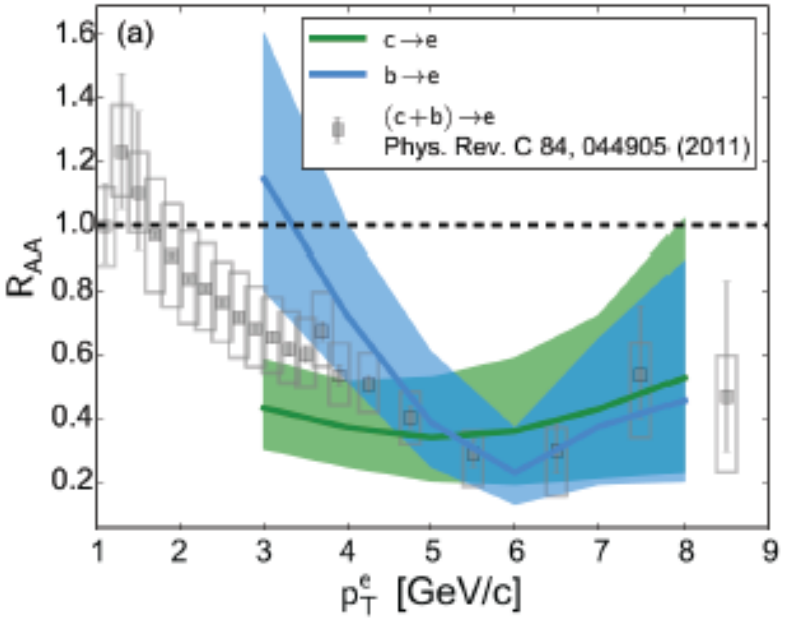

Charm and bottom similarly suppressed at high p_T, bottom is less below ~3 GeV/c !
A factor of ~ 30 more statistics from Run 14 & 16 ! Stay tuned for future updates !